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FOREWORD

Conservation and protection of environments for sustainable existence and developments to ensure the security for water food, health, climate, bio-diversity, energy, etc. is our basic concerns. The challenge of ever growing environmental disaster must be addressed carefully with integrated initiatives, enhanced awareness and research. As peoples of deltaic landmass with vast coastal areas we are the main sufferers and refugee of natural disasters. We as well as world decision makers need to step forward in interdisciplinary researches for control and mitigation, adaptation and dissemination of experiences for sustainable environment management.

The Rajshahi University Journal of Environmental Sciences (RUJES) is a multi-disciplinary journal to promote understanding of environmental issues includes environment and its degradation, conservation, energy use and climate change and their impacts on soil, air, water, food, health, biodiversity, ecology, sustainable development, waste and hazards management, environmental impact assessment etc. Thus, the journal offers a scientific platform for discussing and publishing both in print and online the quality critical reviews, and cutting-edge original and peer-reviewed research achievements focusing on emerging critical environmental issues and challenges.

All the contributors and reviewers are highly acknowledged for their interest, efforts and co-operation. I would like to express my sincere appreciation to the members of editorial board and associates for their support in publishing the volume. I also thank the employees of printing press for their necessary help. Any further suggestion for the improvement of the next issues will be highly appreciated. The Chief Editor and Members of Editorial Board do not bear any responsibility of the views expressed in the papers. The online version of the journal is available at: <http://dept.ru.ac.bd/ies>

Chief Editor

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Manuscripts: The manuscript must be sent in MS Word Document file format containing title of the paper, author's name(s), affiliation(s), author's full postal address(es) and corresponding author's e-mail. Abstract should be within 250 words along with maximum of 5 keywords indicating the objectives, results or conclusion of the study. The text of the full paper should preferably be within 5000 words (max. 10 pages) having the following sub-titles:

- **1. Introduction:** Introduction should be concise and precise relevant to objectives of study.
- **2. Materials and Methods:** Standard and published methods should not be described rather only be cited as references. Any modification or new set up should be stated.
- **3. Results and Discussion:** Results should be presented with appropriate figures, tables, graphs etc. with their proper interpretation.
- **Tables, Graphs and Figures:** The paper should contain maximum of 12 tables, graphs and figures all together. Figures, graphs and photographs should be given as attached file along with appropriate marking numbers in standard BMP format (uncompressed). Original illustrator, graphic or photo files must be supplied with finally accepted manuscript.
- **Acknowledgements (if any):**
- **References.** Appropriate and relevant recent references must be cited following instruction given.

The following format needs to follow for preparation of manuscript:

1. Format Instructions

1.1. Instructions for Typists

Margins are to be set to a width of 15.2 cm, and each page must be typed in Times New Roman 11 points letter for the main text with a 13 points spacing between the lines. The footnotes to be typed in Times New Roman 10 points letter with an 11 points spacing between the lines. Each page must be typed in a page depth of 21.6 cm. On the first page, the title of the paper should start after three blank lines below the journal heading. New paragraphs should be started without any indentation. Title of paper should be typed in bold, 14 point all upper-case letters, with 6 and 12 points spaces above and below respectively. The headings used are:

2. First-Order Heading

These should be typed in bold, 12 point upper- and lower-case letters, with 6 points space above and below the heading. The text after the heading will begin at the left-hand margin (i.e., not indented as for new paragraph).

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This should be typed in 12 point bold with a capital initial for each word at the left-hand margin, 6 points space above and below the heading.

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Special Attention

3.1. Tables

Put a table heading at the top of the table and skip one line above and below the tables. If table heading extends over one line, continue on the second and following lines immediately below the first letter of the heading. Do not use full stop at the end of each table caption. Use horizontal lines above tables, below column headings, and below tables. Use capitals for the first letter of column headings. As far as practicable, arrange the tables in the vertical direction just as in text. Tables and text may appear on the same page. Table 1 is an example of an acceptable table format.

Table 1. Annual rainfall and water table of the study area

Areas	Annual Rainfall (mm)		Water Table (m)	
	Wet Season	Dry Season	Wet Season	Dry Season
Rajshahi	20.4	27.4	90.0	20.4
Natore	30.6	38.6	34.6	31.6
Pabna	45.9	46.9	45.0	43.9

3.2. Figures

Skip 6 points space above and below the figures. Put a figure caption at bottom of the figure and leave 6 points space between figure and caption, and use a full stop at end of the caption. Start second and subsequent lines immediately below the first letter of caption. Skip 6 points space after caption. Figures and text may appear on the same page. Legends, scales, etc. must be large enough to be legible. Give the consecutive numbers for tables and figures, respectively. You can break a paragraph for placing the figure. Try to avoid blank spaces within the text.

3.3. Equations

Equations should be numbered sequentially as follows: Use 1 line spacing instead of a 13 points spacing for the lines from just above to just below the equation.

$$\nabla^2 \phi = 0 \quad (1)$$

3.4. References

In the text, author's last name should be followed by the year of publication; e.g. "(Islam, 2016; Mostofa *et al.*, 1997; Redwan and Shafiuzzaman, 2015) or "Azad (1998) showed that ...". In the list of references, arrange authors' last names in alphabetical order with 0.5 cm indentation for the second and following lines of each reference. When two or more references by the same author are listed, the earlier work should appear first. All references must be cited in the text.

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Sen I, Parua DK, Bera S, Islam MS and Poole I. 2012. Contribution to the Neogene fossil wood record and palaeoecological understanding of Bangladesh. *Palaeontographica, Abteilung B: Palaophytologie, Palaeobotany-Palaeophytology*, **288(1-4)**: 99-133.

For Book:

Blanford WT and Godwin-Austen HH. 1908. *The Fauna of British India, including Ceylon and Burma, Mollusca: Testacellidae and Zonitidae*: Taylor and Francis, London. 311p.

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For Book Edited:

Kumar A and Bidhan D. 1989. *A Text Book of Environmental Science* (eds). (3rd ed) University Press, Dhaka, 525p.

For Dissertation/Thesis:

Mostafa MG. 2000. Thermodynamic simulation of cobalt-carbonate aqueous system. *PhD Dissertation* (unpubl). Faculty of Engineering, Ehime University, Matsuyama, Japan, 200p.

For Report:

WDATCP (Wisconsin Department of Agriculture, Trade, and Consumer Protection) 1991. Report to the state legislature: Agricultural clean sweep demonstration projects, *Madison, WI: Agricultural Resource Management Division*.

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USEPA (United States Environmental Protection Agency) 1995. Water quality standards-Revision of metals criteria, *Fed. Reg.*, **60**: 229-240.

For Proceedings:

Krewitt W, Trukenmueller A, Mayerhofer P and Freidrich R. 1995. An integrated tool for environmental impact analysis. *In: (Kremers H and Pillmann W) Environmental Information Systems*, (eds), pp :90-97.

Online published articles with DOI (with /without page no):

Mutton D and Haque CE. 2004. Human vulnerability, dislocation and resettlement: Adaptation processes of river-bank erosion-induced displacees in Bangladesh. *Disasters*, **28(1)**: 4-62(22), March.

<http://www.ingentaconnect.com/content/bpl/disa/2004/028/001/art0,03;jsessionid=2hcbnbdh3r.alice?format=pri>.

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EVLUATION OF ANTIBACTERIAL, ANTIOXIDANT AND CYTOTOXIC ACTIVITIES OF *Acacia nilotica* (L) LEAF EXTRACT

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Abstract

There are numerous medicinal plants that have the potentialities to treat many diseases, one of these plant is *Acacia nilotica* popularly known as Babla in Bangladesh. Biochemical screening of leaf extract of this plant revealed the presence of carbohydrates, protein, lipids, phenol and flavonoid in moderate concentration. The antibacterial activity of the ethanol extract of *A. nilotica* leaf was evaluated against bacteria using disc diffusion and MIC techniques. Antioxidant potential of the ethanol extract of the plant leaves was evaluated by using 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay. The extract showed significant activity in all antioxidant assays compared to the reference antioxidant ascorbic acid in a dose dependent manner. Cytotoxicity was studied by brine shrimp lethality bioassay. The DPPH free radical scavenging effect of the ethanol extract was compared with standard antioxidant ascorbic acid. IC₅₀ values were found 8.5 µg/ml for the extract and 7.9 µg/ml for ascorbic acid. Total antioxidant activity was also found to increase in a dose dependent manner and also showed strong reducing power. These results suggest that *A. nilotica* may act as chemopreventative agent for antibacterial, antioxidant and protection from free radicals.

Keywords: *Acacia nilotica*, Antibacterial activity, Antioxidant, Cytotoxicity.

1. Introduction

Plants, the most wonderful gift from nature have been used as an origin of drugs. Various types of drugs are obtained from them. These types of plants are known as medicinal plants (Yadav *et al.*, 2010). *Acacia nilotica* is a common, medium sized tree, locally known as ‘Babla’ belonging to the sub-family Mimosaceae. *Acacia* is the most significant genus of family Leguminosae firstly described by Linnaeus in 1773. It is estimated that there are roughly 1380 species of *Acacia* worldwide (Maslin *et al.*, 2003 & Orchard *et al.*, 2003). The plant is a tree with yellow mimosa-like flowers and long grey pods constricted between seeds. The bark and branches are dark with fissures. The branches bear spikes about 2cm long. The leaves are five and densely hairy with 3-6 pairs of pinnae consisting of 10-20 pairs of leaflets narrow with parallel margins and rounded at the apex and with a central midrib closely crowded. The inflorescence consists of bright yellow flowers in axillary head on stalks that are half way up. The flowering period of the plant is between November and March (Mann *et al.*, 2003). The powdered bark of the plant with little salt is used for treating acute diarrhea (Gill, 1992).

Babla plant is therapeutically used as anti-cancer, antitumor, antiscorbutic, astringent, anti-oxidant, natriuretic, anti-spasmodic, diuretic, intestinal pains, nerve stimulant, cold, congestion, coughs, dysentery, fever, hemorrhages, leucorrhea, ophthalmia and sclerosis (Sapna *et al.*, 2011). The plant is considered to be antispasmodic and antidysenteric (Said, 1969). Pods and tender leaves are reported to treat diarrhoea (Nadkarni, 1976). The plant has been shown to exhibit antibacterial (Abd *et al.*, 1992), anti-inflammatory (Dafallah *et al.*, 1996), antiplatelet aggregatory activity (Shah *et al.*, 1997), cestocidal activity (Ghosh *et al.*, 1996),

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antibacterial effects (Sotohy *et al.*, 1997), spasmogenic, vasoconstrictor actions (Amos *et al.*, 1999), antihypertensive, antispasmodic activities (Gilani *et al.*, 1999), inhibitory effect against hepatitis C virus (Hussein *et al.*, 2000) and cytotoxic activity (Tezuka *et al.*, 2000).

There is an increased evidence for the participation of free radicals in the etiology of various diseases like cancer, diabetes, cardio vascular diseases, autoimmune disorders, neurodegenerative diseases, aging; etc (Deshpande *et al.*, 2001). A limited research has been done to evaluate the potentiality of *A. nilotica* plant on antibacterial and antioxidant activities. The objective of the present study was to investigate the antibacterial, antioxidant, and cytotoxic properties of the extract of *Acacia nilotica*. Therefore, systematic research with medicinal plant like Babla (*Acacia nilotica*) may open the door of many therapeutic choices.

2. Materials and Methods

2.1. Collection of Plant

The leaves of the plant *A. nilotica* were collected from Rajshahi University campus, Bangladesh. It was identified and authenticated in the Department of Botany, University of Rajshahi, Bangladesh.

2.2. Test Microorganisms

The pure culture microorganisms were collected from the Institute of Biological Science (IBSc), Department of Pharmacy, University of Rajshahi, and Environmental Microbiology Lab, ICDDR, B Mahakhali, Dhaka, Bangladesh. The bacteria were used for the study of antibacterial activity are *Escherichia coli*, *Shigella sonnei*, *S. dysenteriae*, *S. shiga*, *S. boydii*, *S. flexneri* and *Vibrio cholerae*.

2.3. Preparation of Plant Extract

Fresh leaves of the plant were washed under running tap water and air dried for about one week and then homogenized to fine powder and stored in airtight bottle. The powder of leaves (100 gm) was extracted with 100 ml ethanol using conical flask in a shaking incubator at 28°C for two days. The extract was filtered and evaporated until dryness. The extract was stored at 4°C.

2.4. Antibacterial Assay

The antibacterial activity was investigated using disc diffusion assay (Bauer *et al.*, 1966 & Cruickshank *et al.*, 1968). Reference microorganisms from the stock were streaked onto nutrient agar plates and the inoculated plates were incubated overnight at 37°C. Using a sterile loop, a small portion of the subculture was transferred into test tube containing nutrient broth and incubated (2-4h) at 37°C until the growth reached log phase. Nutrient agar media seeded with standard inoculum suspension was poured in petri-dishes and allowed to solidify. Measured amount of each test samples were dissolved in specific volume of solvent (methanol) to obtain the desired concentrations in an aseptic condition. Sterilized metrical (BBL, Cocksville, USA) filter paper discs were taken in a blank petri-dish under the laminar hood. Then discs were soaked with solutions of test samples and dried. Discs impregnated with extract and blank (solvent ethanol) discs were placed on the petri-dishes with sterile forceps and gently pressed to ensure contact with the inoculated agar surface. Finally the inoculated plates were incubated at 37°C for 24h and the zone of inhibition was measured in millimeters (Bauer *et al.*, 1966, Cruickshank *et al.*, 1968 and Barry, 1976).

2.5. Determination of Minimum Inhibitory Concentration (MIC)

Tube dilution method was done to determine minimum inhibitory concentration of the extracts. A series of two fold dilutions of extracts ranging from 15 mg/ml to 0.3 mg/ml were made in Muller Hinton broth. About 0.1 ml of suspension of each pathogen matched to 0.5 McFarland standard was seeded into each dilution. Two controls

were maintained for each test batch. These included tube containing extract and growth medium without inoculum and organism control i.e. tube containing the growth medium and inoculum. The tubes were incubated at 37°C for 24h and checked for turbidity. Minimum inhibitory concentration was determined as highest dilution of the extract that showed no visible growth.

2.6. Cytotoxicity Test

The brine shrimps used for cytotoxicity test were obtained by hatching 5 mg of eggs of *Artemia salina* in natural seawater after incubation at about 29°C for 24h. The larvae (nauplii) were allowed another 24h in sea water to ensure survival and maturity before use. Five doses of plant extract (100, 200, 400, 600 and 800 ppm) in 5% DMSO and/or sea water were tested. Each extract preparation was dispensed into clean test tubes in 10 ml volumes and tested in duplicates. The concentration of DMSO in the vials was kept below 10 µl/ml. For control, same procedure was followed except test samples. After marking the test tubes properly, 10 living shrimps were added to each of the 6 vials with the help of a pasteur pipette (Meyer *et al.*, 1982). The test tube containing the sample and control were then incubated at 29°C for 24h in a water bath, after which each tube was examined and the surviving nauplii counted. From this, the percentage of mortality was calculated at each concentration.

2.7. DPPH Radical Scavenging Assay

DPPH assay was carried out according to the method described by Soni *et al.*, 2012. About 0.1ml of extract at various concentration (10, 50, 100 and 100µg/ml) are added to 3 ml of a 0.004% methanol solution of DPPH. After 30 min at room temperature, the absorbance was recorded at 517 nm. Radical scavenging activity was calculated by the following formula:

$$\% \text{ Radical Scavenging Activity} = (A_c - A_s / A_c) \times 100$$

Where A_c = Absorbance of control, A_s = Absorbance of sample.

Then percentage DPPH radical scavenging activity was plotted against concentration, and from the graph IC₅₀ was calculated.

2.8. Reducing Power Ability

The reducing power was investigated by the Fe^{3+} - Fe^{2+} transformation in the presence of the extract as described by Fejes *et al.* (2000). The Fe^{2+} can be monitored by measuring the formation of Perl's Prussian blue at 700 nm (Meir *et al.*, 1995). In 1.0 ml of the extract (6.25-100 µg/ml), 2.5 ml of phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide were incubated at 50°C for 30 min and 2.5 ml of 10% trichloroacetic acid was added to the mixture and centrifuged for 10 min at 3000 rpm. About 2.5 ml of the supernatant was diluted with 2.5 ml of distilled water and shaken with 0.5 ml of freshly prepared 0.1% ferric chloride. The absorbance was measured at 700 nm. Butylated hydroxytoluene (6.25-100 µg/ml) was used as the standard. All tests were performed in triplicate and the graph was plotted with the average of the three determinations.

2.9. Phosphomolybdate Method

The total antioxidant capacity of the extract was determined by phosphomolybdate method using α -tocopherol as the standard (Jayaprakasha *et al.*, 2002). An aliquot of 0.1ml of the extract (100 µg) solution was combined with 1.0 ml of reagent (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The tubes were capped and incubated in a boiling water bath at 95°C for 90 min. After the samples had cooled to room temperature, the absorbance was measured at 695 nm against the blank using an UV spectrophotometer. The blank solution contained 1.0 ml of reagent solution and the appropriate volume of the same solvent used for the sample and it was incubated under same conditions as rest of the sample. The total antioxidant capacity was expressed as µg equivalents of α -tocopherol by using the standard tocopherol graph.

2.10. Estimation of Total Phenolic Content

Total soluble phenolics of the extract were determined with Folin-Ciocalteu reagent using pyrocatechol as the standard (Gulcin *et al.*, 2004). An aliquot of 0.1 ml suspension of 1 mg of the extract in water was totally transferred to a 100 ml Erlenmeyer flask and the final volume was adjusted to 46 ml by the addition of distilled water. Folin-Ciocalteu reagent (1 ml) was added to this mixture, followed by 3 ml of 2% sodium carbonate 3 min later. Subsequently, the mixture was shaken for 2 h at room temperature and the absorbance was measured at 760 nm. The concentration of total phenolic compounds in the extract was determined as μg pyrocatechol equivalent by using the standard pyrocatechol graph.

2.11. Estimation of Total Flavonoid Content

Total soluble flavonoid content of the extract was determined with aluminium nitrate using quercetin as the standard (Hsu, 2006). 0.5 ml of the extract was added to 1.5 ml of 80 % ethanol. An aliquot of 0.5 ml was added to test tubes containing 0.1 ml of 10 % aluminium nitrate, 0.1 ml of 1 M potassium acetate and 4.3 ml of 80 % ethanol. The absorbance of the supernatant was measured at 415 nm after incubation at room temperature for 40 min. The total flavonoid content in the extract was determined as μg quercetin equivalent by using the standard quercetin graph.

3. Results

3.1. Phytochemical Analysis of Extract

The results of different chemical tests for phytochemical analysis of crude ethanolic extracts are shown in Table 1. The leaves extract of *A. nilotica* contained alkaloid, carbohydrates, saponins, tannins, flavonoids, cardiac glycosides, anthraquinone, steroid and triterpenes, terpenoid, gum, amino acids and proteins but fixed oils and fat were absent.

Table 1. Phytochemical analysis of *A. nilotica* leaves extract

Tests	Ethanol Extract
Alkaloids	+
Carbohydrate	+
Anthraquinones (Free state)	+
Anthraquinones (Combined state)	+
Cardiac Glycosides	+
Saponins	+
Steroid & Triterpenes	+
Flavonoids	+
Phenol/Tannins	+
Amino acid & protein	+
Terpenoid	+
Fixed oil & fat	-
Gum	+

(+ Present, - Absent)

3.2. Antimicrobial Activity and MIC of the Extracts Against Bacteria

The ethanolic extract of the leaves of *A. nilotica* showed significant activity against bacteria. The MIC of ethanol extract was low 1.6 mg/ml in *S. sonnei* (Table 2). The lower MIC is an indication of high effectiveness of extract. MIC for *E. coli* was 3.2 mg/ml, *S. dysenteriae* 6.4 mg/ml, *S. shiga* 3.2 mg/ml, *S. boydii* 12.8 mg/ml, *S. flexneri* 6.4 mg/ml and *V. cholerae* 12.8 mg/ml for ethanol extract of *A. nilotica* leaves. The MIC of extract was high 12.8 mg/ml for *S. boydii* & *V. cholera* in this study. No zone showed by the control.

Table 2. *In Vitro* antibacterial activity of ethanol extract of *A. nilotica* leaves with their MIC against bacteria

Sl. no.	Name of Bacteria	Zone of inhibition (mm)	MIC (mg/ml)
1	<i>E. coli</i>	10.67	3.2
2	<i>S. dysenteriae</i>	9.33	6.4
3	<i>S. shiga</i>	9.00	3.2
4	<i>S. sonnei</i>	8.33	1.6
5	<i>S. boydii</i>	8.67	12.8
6	<i>S. flexneri</i>	9.67	6.4
7	<i>V. cholerae</i>	10.67	12.8

3.3. Cytotoxic, DPPH Radical Scavenging and Antioxidant Activities

Table 3 shows brine shrimp lethality bioassay, the extract showed lethality against the brine shrimp nauplii. It showed different mortality rate at different concentrations from the plot of percent mortality *versus* log concentration on the graph paper LC₅₀.

Table 3. LC₅₀ values, 95%, regression equations and χ^2 values (along with their df) of the ethanol extract of *A. nilotica* leaves against *A. salina* nauplii

Extract	Exposure (h)	Concentration (ppm)	Log concentration	No. of kill nauplii	% mortality	Regression equations	LC ₅₀ (ppm)
<i>A. nilotica</i> leaves Ethanol	24	800.000	2.903	8	26.667	$Y = 0.601 + 1.706X$	395.581
		600.000	2.778	6	20.000		
		400.000	2.602	4	13.333		
		200.000	2.301	3	10.000		
		100.000	2.000	2	6.667		

Table 4. DPPH radical scavenging activity of ethanolic extract of *A. nilotica* leaves

Sample	Concentration ($\mu\text{g/ml}$)	Absorbance			% of scavenging			% of scavenging mean \pm STD	IC ₅₀ ($\mu\text{g/ml}$)
		a	b	c	a	b	c		
Ethanol extract of <i>A. nilotica</i>	3.125	0.526	0.539	0.513	14.47	12.36	16.59	14.47333 \pm 2.115002	8.5
	6.25	0.403	0.354	0.377	34.47	42.44	38.70	38.53667 \pm 3.98751	
	12.5	0.261	0.166	0.242	57.56	73.01	60.65	63.74 \pm 8.175372	
	25	0.051	0.033	0.100	91.71	94.63	83.74	90.02667 \pm 5.636775	

The ethanol extract of *A. nilotica* leaves demonstrated H-donor activity. The highest DPPH radical scavenging activity was detected in ethanol extract (IC₅₀ 8.5 mg/ml). These activities are less than that of ascorbic acid (IC₅₀ 7.9 $\mu\text{g/ml}$). Table 4 shows the reductive capabilities of the extract of *A. nilotica* when compared to the standard, BHT. The ethanol extract of *A. nilotica* showed the reducing ability (absorbance 2.948667). However, the activity was less than the standard, BHT (absorbance 3.017).

Table 5. Determination of total antioxidant capacity of ethanolic extract of *A. nilotica* leaves

Sample (extract)	No. of sample	Concentration ($\mu\text{g/ml}$)	Absorbance	Weight m (gm)	Concentration C (mg/ml)	$A=(c \times v)/m$	Total antioxidant (mg/gm)
$\text{C}_2\text{H}_5\text{OH}$ extract	1	100	0.426	0.0001	0.01360	68	63.475 ± 6.40
	2	100	0.355	0.0001	0.01179	58.95	
	3	50	0.220	0.00005	0.00836	83.6	82.95 ± 0.92
	4	50	0.215	0.00005	0.00823	82.3	
	5	25	0.085	0.000025	0.00492	98.4	107.3 ± 12.59
	6	25	0.120	0.000025	0.00581	116.2	
	7	12.5	0.035	0.0000125	0.00365	146	165.4 ± 27.44
	8	12.5	0.073	0.0000125	0.00462	184.8	
	9	6.25	0.023	0.00000625	0.00335	268	295.2 ± 38.47
	10	6.25	0.050	0.00000625	0.00403	322.4	

Total antioxidant capacity of ethanolic extract of *A. nilotica* leaves at 100, 50, 25, 12.5 and 6.25 $\mu\text{g/ml}$ is 63.475 ± 6.40 , 82.95 ± 0.92 , 107.3 ± 12.59 , 165.4 ± 27.44 and 295.2 ± 38.47 mg/g, vitamin E equivalents (Table 5).

3.4. Determination of Total Phenolic and Flavonoids Content

Table 6. Determination of total phenolic content of ethanol extract of *A. nilotica* leaves

Sample	No. of sample	Concentration ($\mu\text{g/ml}$)	Absorbance	m(gm)	C(mg/ml)	$A=(c \times v)/m$	Total phenolic (mg/gm)
Ethanol extract	1	800	3.784	0.0008	0.322	201.25	193.96 ± 7.87
	2	800	3.685	0.0008	0.312	195.00	
	3	800	3.505	0.0008	0.297	185.625	
	4	400	2.638	0.0004	0.2202	275.25	258.05 ± 17.38
	5	400	2.323	0.0004	0.1924	240.50	
	6	400	2.485	0.0004	0.2067	258.375	
	7	200	1.536	0.0002	0.1227	306.75	296.67 ± 10.14
	8	200	1.486	0.0002	0.1183	295.75	
	9	200	1.444	0.0002	0.1146	286.50	

Total phenolic content of ethanolic extract of *A. nilotica* leaves at 800 $\mu\text{g/ml}$, 400 $\mu\text{g/ml}$ and 200 $\mu\text{g/ml}$ is 193.96 ± 7.87 , 258.05 ± 17.38 and 296.67 ± 10.14 mg/g, PE (Table 6).

Table 7. Determination of total flavonoids content of ethanol extract of *A. nilotica* leaves

Sample	No. of sample	Concentration ($\mu\text{g/ml}$)	Absorbance	m(mg)	C(mg/ml)	$A=(c \times v)/m$	Mean \pm STD (mg/gm)
Ethanol extract	1	800	0.937	0.0008	0.21586	134.9125	114.56 ± 22.12
	2	800	0.816	0.0008	0.18836	117.725	
	3	800	0.628	0.0008	0.14564	91.025	

Total flavonoids content of ethanol extract of *A. nilotica* leaves at 800 $\mu\text{g/ml}$ is 114.56 ± 22.12 mg/gm, Q.E (Table 7).

4. Discussion

The results of preliminary phytochemical analysis of ethanol extract of leaves of *A. nilotica* in the present study revealed the presence of alkaloids, saponins, cardiac glycosides and tannins. This finding is consistent with Banso (2009). In contrast, the present study showed presence of flavonoids in the ethanol extract of leaves of *A. nilotica* which does not correlate with studies by Banso (2009). However the findings in present study correlate with preliminary analysis of stem bark ethanol extract by Siddiqui *et al.* (1991) who found the presence of flavonoids in the stem bark extract of *A. nilotica*. The antibacterial potential of ethanol extract of leaves of *A. nilotica* was investigated against some of the pathogens like *E. coli*, *S. dysenteriae*, *S. shiga*, *S. boydii*, *S. sonnei*, *S. flexneri* and *V. cholerae*. The extract exhibited inhibitory action on the pathogens during this study. This finding correlates with reports of Dabur *et al.* (2007). The cytotoxic activity of the ethanol extract of dried leaves of *A. nilotica* was tested by using brine shrimp lethality bioassay. It is a recent development in the bioassay for the bioactive compounds. Brine shrimp lethality bioassay indicates cytotoxicity as well as a wide range of pharmacological activities such as antimicrobial, pesticidal, antitumor (Anderson *et al.*, 1988). The extract was found to show potent activity against the brine shrimp nauplii.

Free radicals are known to play a definite role in a wide variety of pathological manifestations. Antioxidants fight free radicals and protect us from various diseases. They exert their action either by scavenging the reactive oxygen species or protecting the antioxidant defense mechanisms.

DPPH assay is one of the most widely used methods for screening antioxidant activity of plant extracts (Nanjo *et al.*, 1996). DPPH is a stable, nitrogen-centered free radical which produces violet colour in ethanol solution. It was reduced to a yellow coloured product, diphenylpicryl hydrazine, with the addition of the fractions in a concentration-dependent manner. The reduction in the number of DPPH molecules can be correlated with the number of available hydroxyl groups. All the extracts showed significantly higher inhibition percentage (stronger hydrogen-donating ability) and positively correlated with total phenolic content.

The transformation of Fe^{3+} into Fe^{2+} in the presence of various extracts was measured to determine the reducing power ability. The reducing ability of a compound generally depends on the presence of reductones (antioxidants), which exert the antioxidant activity by breaking the free radical chain by donating a hydrogen atom (Meir *et al.*, 1995). The antioxidant principles present in the extracts of *A. nilotica* caused the reduction of Fe^{3+} / ferricyanide complex to the ferrous form, and thus proved the reducing power ability.

The phosphomolybdate method has been routinely used to evaluate the total antioxidant capacity of the extracts (Prieto *et al.*, 1997). In the presence of the extracts, the Mo (VI) is reduced to Mo (V) and forms a green coloured phosphomolybdenum V complex which shows maximum absorbance at 695 nm. All the extracts possessed antioxidant activity.

Phenolics are ubiquitous secondary metabolites in plants and possess a wide range of therapeutic uses such as antioxidant, antimutagenic, anticarcinogenic, free radical scavenging activities and also decrease cardiovascular complications (Yen *et al.*, 1993). The scavenging ability of the phenolics is mainly due to the presence of hydroxyl groups. Total phenolic assay by using Folin-Ciocalteu reagent is a simple, convenient and reproducible method. It is employed routinely in studying phenolic antioxidants (Huang *et al.*, 2005). Flavonoids are a group of polyphenolic compounds, which exhibit several biological effects such as antiinflammatory, antihepatotoxic, antiulcer, antiallergic, antiviral, anticancer activities. They also inhibit enzymes such as aldose reductase and xanthine oxidase. They are capable of effectively scavenging the reactive oxygen species because of their phenolic hydroxyl groups and are potent antioxidants (Cao *et al.*, 1997). In view of their wide pharmacological and biological actions, they have a greater therapeutic potential. The presence of high phenolic and flavonoid content in the extract of *Acacia nilotica* has contributed directly to the antioxidant activity by neutralising the free radicals.

4. Conclusions

Ethanol extract of *Acacia nilotica* leaves demonstrated significant growth inhibition effects against bacteria. The extract showed strong antioxidant activity, reducing power ability and free radical scavenging activity due to the presence of phenolic, flavonoid compounds, and other phyto chemicals. Therefore, it could be used as a source of antioxidant as well as chemotherapeutic agent.

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CHARACTERISTICS OF HOUSEHOLD SOLID WASTE AND ITS MANAGEMENT IN PABNA MUNICIPALITY

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Abstract

This study identifies the determinants affecting the waste generation and investigates the aspects of awareness regarding household level waste management practices. The methodology includes a sampling and questionnaire survey, waste collection, segregation and measurement of composition and necessary analysis of collected information. The study finds the household solid waste generation rate of 1.8 kg per day per household positively correlated with family size, education level of the household owner and family income. These three determinants can explain 77% of the variance of household solid waste generation rate. Per capita household solid waste generation in surveyed area is 0.38 kg per person per day is found to be positively correlated with household owner's education and family income and 60% of the variance in per capita household solid waste generation can be explained by these two determinants. Generated garbage are diverse in category and 76% by weight are biodegradable in nature. Waste management practices in the surveyed area are performed by municipal authority and the inhabitant satisfaction is 57.7%. 72% of the households are eager to take waste management services and 55% among them are willing to pay 0.6 US\$ per month as a service payment. Collection of waste from the homesteads before 9.00 AM in the morning is preferable to 48% of the households. Public awareness is affected by the outdated municipal waste management practice and comprehensive waste management planning and implementation is a promising option.

Keywords: Pabna Municipality, Household solid waste, Waste management

1. Introduction

Waste is regarded as the byproducts and end products of production and consumption of human civilization (Singh *et al.*, 2014; European Union, 2008). Municipal waste generation is a result of human activities related to consumption patterns depends on demographic, social, cultural, economic and environmental factors (Oribe-Garcia *et al.*, 2015; Li *et al.*, 2011). Population growth, economic development and rapid urbanization result in increased rate of municipal solid waste generation with the rise of community living standards (Guerrero *et al.*, 2012; Minghua *et al.*, 2009). Municipalities in developing countries experience waste generation from households (55-80%), commercial or market areas (10-30%) with varying quantities from streets industries and other sectors (Miezah *et al.*, 2015; Okot-Okumu, 2012). In Bangladesh mainly municipal authorities are responsible for waste management in cities to provide an effective waste management system to the inhabitants often face problems beyond their ability (Sujauddin *et al.*, 2008) due to organizational, financial and multidimensional system barriers (Guerrero *et al.*, 2012; Burnley, 2007). Poor waste management practices and associated public health impacts remain severely problematic in many developing countries due to a variety of reasons (Marshall and Farahbakhsh, 2013; Konteh, 2009). Municipal solid waste management is one of the most costly urban services which typically absorbs 1% of gross national product (GNP) and 20-40% of municipal revenue in developing countries (Aliu *et al.*, 2014). It is a highly visible municipal service that involves large expenditures in terms of investments, operational environmental costs (Faccio *et al.*, 2011). The municipalities of Bangladesh are facing problems due to physical planning issues, governmental systems and

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policies, administrative and managerial procedures and people's attitude and behavior to municipal solid waste (Hasan, 1998). Conservancy departments of city corporations and municipal authorities perform the urban and or municipal waste management (Sujauddin *et al.*, 2008; Mamun and Hossain, 2012). A number of research work on municipal solid waste have already been conducted in Bangladesh (Hasan, 1998; Sufian and Bala, 2006; Afroz *et al.*, 2007; Sujauddin *et al.*, 2008; Bhuiyan, 2009; Bari *et al.*, 2012^a; 2012^b; Hossain *et al.*, 2014) mainly focus on big cities (Dhaka, Chittagong, Khulna and Rajshahi) containing only 32.03% of total urban population of this country (BBS, 2012). From these regards the and objectives of the study are to identification of the micro level socioeconomic and demographic determinants (factors) affecting the point of source of waste generation in an identical municipal area rather than the big cities, quantification and determination of the amount and composition of generated waste, investigation of awareness of waste management practices among inhabitants and discovery of potential impacts of identified determinants. Therefore, this study leads to generate a regional level comprehensive information for planning and implementation of relevant waste management activities in developing countries like Bangladesh with growing waste management challenges. The study was carried out on purposively selected Monsurabad Residential area under Pabna municipality (24°00' N and 89°15' E) located in the north western part of Bangladesh and 219 km away from the capital city (Dhaka). The municipal authority was formed in 1876. It serves as a home of 144,000 people (BBS, 2012) and one of the major economic hubs of this region. Monsurabad residential area is the only planned and fastest growing residential area of this municipality.

2. Materials and Methods

The number of total households is 346 as counted during the reconnaissance survey. The study was conducted from November, 2016 to November, 2017. The main tool for data collection was a structured questionnaire designed in the local language. For Monsurabad residential area, the size of the sample was determined 125 by using the following methodology widely used in different studies (Gomez *et al.*, 2008; Gallardo *et al.*, 2012; Fei-Baffoe *et al.*, 2014).

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2 (N-1) + z^2 \cdot p \cdot q} \quad (1)$$

Where, n stands for the size of the sample, p is the sample proportion and $q=1-p$. This study used an initial estimate of p ($p=0.15$) based on a pilot study prior to the questionnaire survey. The value of z was taken 1.96 as per the table of the area the under normal curve at a given confidence level of 95%. The value of e was 0.05 as the estimation was considered to be within 5% of the true value. The N was the size of the population. To collect the residential per capita solid waste generation plastic bags were supplied to each household during the questionnaire survey. Collected waste from each household within the plastic bag were segregated (Enayetullah *et al.*, 2005; Sujauddin *et al.*, 2008; Otoma *et al.*, 2013) weighted and recorded for each day from every surveyed household. Different income groups were identified on the basis of household's monthly income by surveying and following of relevant studies (Sujauddin *et al.*, 2008; Otoma *et al.*, 2013; Pirani *et al.*, 2015). Besides household's income, number of residents per dwelling, household owner's age and education level, staying period at current location and average hours spent by parents at home per day are selected as determinants of per capita solid waste generation based on reconnaissance survey and review of relevant literatures (Afroz *et al.*, 2007; Sujauddin *et al.*, 2008; Otoma *et al.*, 2013; Aliu *et al.*, 2014; Pirani *et al.*, 2015). The determinants represent the socioeconomic and demographic characteristics of households and may affect the quantity of waste generation (Sujauddin *et al.*, 2008). To analyze the degree of correlation of the determinants with per capita household solid waste generation (HSWG) Pearson's product moment correlation analysis is performed by using the statistical package for social science (SPSS).

$$r_{xy} = \frac{\sum (x_i - \bar{X})(y_i - \bar{Y})}{n \sigma_x \sigma_y} \quad (2)$$

Where r_{xy} is the Karl Pearson's coefficient of correlation, X_i and Y_i stands for the i th value of the variables (Per capita HSWG as dependent and the determinants as independent) and \bar{X} and \bar{Y} are the variable means. Standard deviations are denoted by σ_x and σ_y along with the number of pairs as n . Significantly correlated determinants with per capita HSWG are then evaluated with least square regression analysis to identify their potential effects on per capita HSWG.

$$Y = a + bX \quad (3)$$

Where the symbol Y denotes the value of per capita HSWG for the given value of the correlated determinants (X). The values of constants a and b are derived from the default equations by using SPSS. Information regarding managerial aspects like respondent's knowledge on waste segregation and willingness to cooperate with household waste management are also examined and interpreted to generate comprehensive information.

3. Results and Discussion

The distribution of the selected determinants among the sample population shows that the average size of the surveyed households is 4.76 is in line with the Population and Housing Census of 2011 published by Bangladesh Bureau of Statistics (BBS, 2012). About 44% of the surveyed households have a size of 4 persons per dwelling. The average age of household owner is around 50 and about 30% of the surveyed household owner is aged ranges from 40 to 50 years. The mean year of schooling of respondent household owner's is 11.68 and about 30% of them have an education level of 12th class. About 44% of the families are staying here for a period ranges from 6 months to 5 years are mostly tenants. The study also found that about 30% of the families who are landlords are staying here for more than 20 years. The income groups are identified as 0-20000 BDT, 20001-40000 BDT, 40001-60000 BDT and more than 60000 BDT (1 US\$=80 BDT). 20001-40000 BDT is the most numerous (48%) among the income groups. In terms of the average hours spent by parents at home per day 15-18 hours (including all activity) range has a valid percentage of 37.5% among the interviewed household. The study finds no information regarding hours spent by parents at home in case of 4% of the sample population.

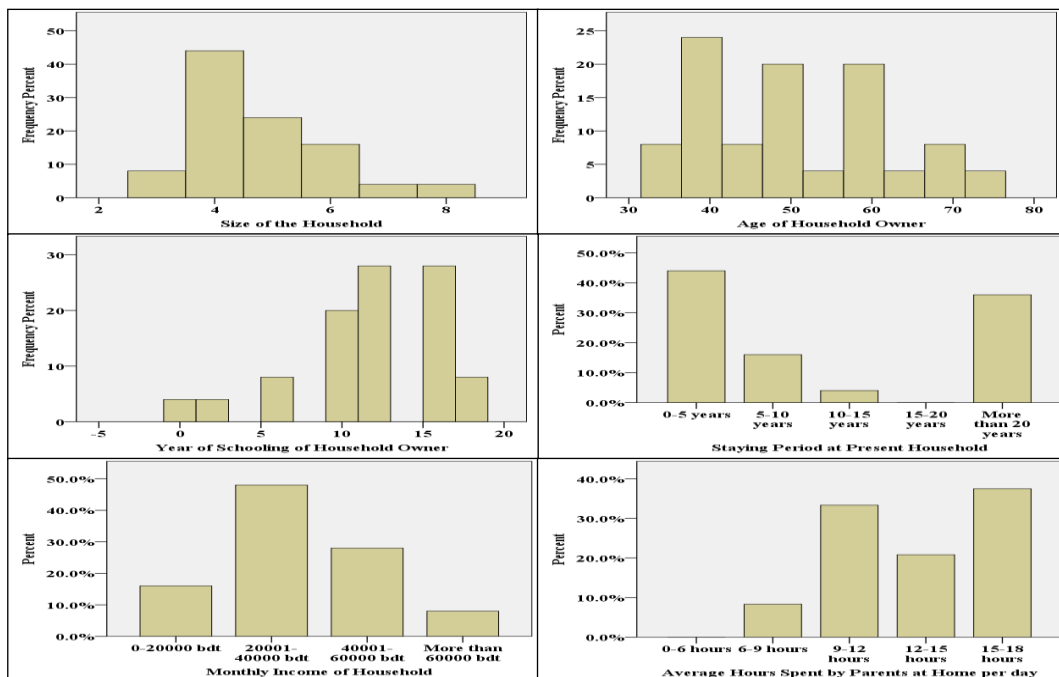


Figure 1. Distribution of the determinants (independent variables) among the sample population.

Residential (household) waste comprises about 30% of total municipal waste stream in Asia (World Bank, 1999). The results of the survey indicated that solid waste generation in Monsurabad residential area of Pabna Municipality is about 1.8 kg per household per day. During survey work, collected wastes from each household were carefully segregated by following the methodology of some empirical studies (Enayetullah *et al.*, 2005; Sujauddin *et al.*, 2008).

Table 1. Household solid waste category and composition

Type	Item	Nature			Composition (%)
		Organic/ biodegradable / Green	Inorganic/ Disposable	Recyclable	
Green	Food, Vegetable, Fruits	•			72.4
Paper	Paper, Book, Packages,	•		•	4.1
Disposable paper	Tissue, Diaper, container/ pouch		•		2.7
Metal	Can, Jar, Tin, Metal			•	.3
Plastic	Plastic, Polythene, Rubber			•	5.3
Textile	Rugs, Jute, Cloth		•		1.6
Glass	Glass stuff, Ceramic			•	.5
Soil	Rock, brick, dirt, pot		•		11.3
Wood	Broken furniture		•	•	1.8

Composition of household solid waste is quite diverse in category and organic waste accounts for about 76% of total value are representative of municipal waste composition of Bangladesh (Bari *et al.*, 2012^b). The household waste generation rate in Monsurabad residential area by a person is 0.38 kg/day is in line with the estimated per capita waste generation rate of six major urban areas of Bangladesh (Enayetullah *et al.*, 2005; Sujauddin *et al.*, 2008). The generation of solid waste per household per day is found to be positively correlated with the size of the household ($r_{xy} = 0.526$, $p < 0.01$), year of schooling of household owner ($r_{xy} = 0.532$, $p < 0.01$) and monthly income of household ($r_{xy} = 0.829$, $p < 0.01$) and the correlation results with household owner's age, period of staying at present location and hours spent by parents at home are statistically insignificant (Table 2).

Table 2. Correlations between selected determinants and household solid waste generation

		Household Size	Household Owner's Age	Household Owner's Year of Schooling	Period of Stay at Present Household	Household monthly Income (BDT)	Av. Hours Spent by Parents at Home/day	Waste per Household (kgs)	Household Waste Generation/capita/day (kgs)
Household Size	<i>r</i>	1	0.187	0.159	0.003	0.391	-0.089	0.526**	0.009
	<i>p</i>		0.372	0.446	0.988	0.053	0.671	0.007	0.965
Household Owner's Age	<i>r</i>	0.187	1	0.116	0.210	0.077	0.264	0.202	0.148
	<i>p</i>	0.372		0.580	0.313	0.713	0.203	0.332	0.479
Household Owner's Year of Schooling	<i>r</i>	0.159	0.116	1	0.000	0.434*	-0.262	0.532**	0.580**
	<i>p</i>	0.446	0.580		0.999	0.030	0.206	0.006	0.002
Period of Stay at Present Household	<i>r</i>	0.003	0.210	0.000	1	-0.097	0.120	0.097	0.120
	<i>p</i>	0.988	0.313	0.999		0.646	0.567	0.646	0.569
Household Income (BDT)	<i>r</i>	0.391	0.077	0.434*	-0.097	1	-0.023	0.829**	0.715**
	<i>p</i>	0.053	0.713	0.030	0.646		0.914	0.000	0.000
Av. Hours Spent by Parents at Home/day	<i>r</i>	-0.089	0.264	-0.262	0.120	-0.023	1	0.027	0.089
	<i>p</i>	0.671	0.203	0.206	0.567	0.914		0.897	0.672
Waste generation/ Household (kgs)	<i>r</i>	0.526**	0.202	0.532**	0.097	0.829**	0.027	1	0.839**
	<i>p</i>	0.007	0.332	0.006	0.646	0.000	0.897		0.000
Household Waste Generation/capita/day (kgs)	<i>r</i>	0.009	0.148	0.580**	0.120	0.715**	0.089	0.839**	1
	<i>p</i>	0.965	0.479	0.002	0.569	0.000	0.672	0.000	
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									
<i>p</i> = Sig. (two tailed)									

Correlation between HSWG and year of schooling can be explained as the rise of living standard with higher education level along with income which means more consumption and more wastages (Sujauddin *et al.*, 2008). Table 02 also shows a positive correlation ($r_{xy} = 0.434$, $p < 0.05$) between year of schooling of household owner and monthly income of household likely to be usual in a typical municipal environment in Bangladesh. Of course, family size does matter for the quantity of waste at a household because more members mean more consumption. But, in case of this study size of the household does not affect the per capita HSWG (Table 2). Per capita HSWG is positively correlated with year of schooling of household owner ($r_{xy} = 0.580$, $p < 0.01$) and household monthly income ($r_{xy} = 0.715$, $p < 0.01$). Other indicators are insignificant. This analysis also reveals that per capita HSWG and waste per household per day have a strong positive correlation with household monthly income statistically significant at the 0.01 level. Among the identified income groups 'more than 60000 BDT' has the highest level of household waste generation.

Table 3. Monthly income wise solid waste generation of the surveyed households

Household monthly income groups	Average per capita HSWG (Kg)	Average amount of household waste per day (Kg)
0-20000 BDT	0.21	0.87
20001-40000 BDT	0.35	1.56
40001-60000 BDT	0.50	2.37
more than 60000 BDT	0.52	3.33

Waste generation per household per day is found positively correlated with three independent determinants namely 'size of the household', 'year of schooling of household owner' and monthly 'household income'. Besides per capita HSWG per day is positively correlated with 'year of schooling of household owner' and monthly 'household income'. Both two category of waste generation are considered as dependent variable in linear regression analysis with the correlated independent determinants. Results of two linear regression model are summarized in the following tables.

Table 4. Results of multiple regression analysis between independent determinants and household solid waste generation

Model	R	R ²	Adjusted R ²	F	P
1	.879	.773*	.741	23.88	.000
2	.775	.601**	.564	16.554	.000

* Dependent: household waste generation per kg per day.

Independent: (Constant), size of the household, year of schooling of household owner, monthly household income.

** Dependent: per capita HSWG per day.

Independent: (Constant), year of schooling of household owner, monthly household income.

The significantly fitted above models revealed that the three independent determinants can explain 77% of the variance in household waste generation per day and 60% of the variance of per capita HSWG per day can be explained by monthly household income and year of schooling of household owner. In both models monthly household income is revealed as the most significant determinant with p values of 0.000 and 0.001 respectively. The results of bivariate simple regression with household waste generation per day and per capita HSWG where monthly household income is taken as independent variable indicate that the monthly income has an explanation of variance of 68% ($p = 0.000$) in case of waste generation per household and 51% ($p = 0.000$) of per capita HSWG.

Like most of the urban areas of Bangladesh the municipal authority of Pabna undertake all responsibilities of municipal waste management and currently it is in a back breaking situation with its limited resources, technologies and manpower (Mamun and Hossain, 2012). The effectiveness of any waste management program regarding household waste management requires an effective support from the households and a well-informed and concerned public can significantly facilitate program implementation and ensure success (Sujauddin *et al.*,

2008). This study investigates the awareness of waste management practices at household level to generate a regional level comprehensive information. It is found that for the surveyed area 83.2% of the households get municipal waste management services and service level satisfaction is 57.7%.

Table 5. Distribution of solid waste managerial aspects of surveyed households

Variable	Frequency	Percentage
<i>1. Get services from the municipality</i>		
Yes	104	83.2
No	8	6.4
Do not take service	13	10.4
Total	125	100.0
<i>2. Satisfaction regarding present service</i>		
Satisfied	60	57.7
Not satisfied	44	42.3
Total	104	100.0
<i>3. Willingness to take service from the municipality/local waste management initiative</i>		
Yes	90	72.0
No	5	4.0
No information	30	24.0
Total	125	100.0
<i>4. Rationality of payment for service</i>		
Rational	68	75.6
Not rational	17	18.9
No information	5	5.5
Total	90	100.0
<i>5. Willingness to pay for service (BDT)</i>		
0-20	21	30.9
21-40	2	2.9
41-60	38	55.9
61-80	0	0.0
81-100	6	8.9
>100	1	1.4
Total	68	100.0
<i>6. Preferable time for waste collection</i>		
Before 9.00 AM	60	48.0
9.00 AM-10.00 AM	23	18.4
10.00 AM-11.00 AM	11	8.8
11.00 AM-12.00 PM	0	0.0
12.00 PM-1.00 PM	0	0.0
1.00 PM-2.00 PM	0	0.0
2.00 PM-3.00 PM	0	0.0
After 3.00 PM	28	22.4
No information	3	2.4
Total	125	100.0
<i>7. Preferable place for dumping</i>		
Open space	5	4.0
To the collector	5	4.0
Lawn	50	40.0
Dustbin	65	52.0
Total	125	100.0
<i>8. Self-role in household solid waste management</i>		
Collection	95	76.0
Collection and Segregation	15	12.0
Recycle	10	8.0
Dispose	5	4.0
Total	125	100.0
<i>9. Idea about waste segregation</i>		
Yes	80	64.0
No	45	36.0
Total	125	100.0
<i>10. Why segregation?</i>		
Waste reduction	12	15.0
Cost reduction	21	26.3
Pollution minimize	38	47.5
Composting	9	11.2
Total	80	100.0

The study found 72.0% of the surveyed households are eager to get waste management services and 75.6% among them are rational to make a monthly payment. Around BDT 50 is the choice amount to 55.9% of the families rational to payment. Before 9.00 AM in the morning is the preferable waste collection period from the households. According to this study surveyed families preferred their waste dumping place as dustbin (52.0%) and lawn (40%) is not identical to some empirical studies (Sujauddin *et al.*, 2008). That is due to the municipal residential collection system being practiced for a long period of time. Households used to dump their garbage to the available dustbin nearby or in an open space or lawn in front of homestead and the collectors of municipality perform their operation from the said locations. This usual practice also influenced the awareness regarding self-role in household solid waste management. Collection is the found answer for 76.0% respondent. Knowledge of source separation or segregation is found 64.0% and about half of them (47.5%) identified it as a tool for reducing pollution. Waste management system of Pabna municipality is characterized by outdated collecting and dumping practice with no involvement of local or community based organizations.

4. Conclusion

Reduction, collection, transportation, processing and disposal are the required activities to the municipal waste management system affiliated with public health, resource conservation, urban aesthetics and environmental sustainability. Population increase in urban areas due to uncontrollable ruralurban migration and unplanned urban expansion pressurize municipal waste management system to all extents. This study tries to explore the potential impacts of micro level socio economic determinants on solid waste generation at the household level and finds positive effects of income and education. The municipal services are outdated and inhabitants are accustomed to the practices. Public awareness is influenced in a couple of ways and household satisfaction level is comparatively poor. In the case of managerial aspects of households practices like segregation, source separation and reuse are absent. Knowledge about these sustainable practices is also influenced by municipal services. These acute information are convenient to any kind of waste management planning and implementation including community participation.

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ESTIMATION OF PEAK GROUND ACCELERATION IN BANGLADESH

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Abstract

Distributions of peak ground acceleration (PGA) over Bangladesh in the form of maps, have been estimated in the present work using amplitude-distance relation. PGA in seismic understanding is a valuable measure for studying the ground condition of the earth. In order to estimate such distributions, the whole study area has been divided into twelve primary seismic zones. Apparent investigations of fault characteristics, seismicity status and geographic pattern were considered to delineate the primary zones. A seismicity pattern of the study area using 25 years data from 1990 to 2015, has been prepared to characterize maximum and minimum PGA effects to the 12 seismic zones of the study area from nearby earthquake events. Distributions of PGA approximately at 40 m x 40 m grid points, have been estimated for twelve seismic zones. Earthquake events, for maximum and minimum PGA, have been identified for each zone from a number of nearby events. Then using the identified events, maximum and minimum PGA distributions have been estimated and averaged for whole Bangladesh. Both arithmetic and quadratic average have been computed over estimated distributions and presented in the form of maps. Computed arithmetic average maximum PGA distributions, were approximately equal to or less than 0.034g, which indicate the area is not being under threat for potential damages. However, computed quadratic mean of maximum PGA distributions at six locations at Chandpur, Mymensingh, Sylhet, Rangpur, part of Chittagong and north-east region of Khulna division, were approximately or equal to 0.063g, which render the locations are under threat for moderate to heavier damages. A seismic zone map of the study was thus presented according to estimated quadratic mean of maximum PGA distributions. The map aptly describes the seismic status of Bangladesh.

Keywords: Ground motion, Earthquake, Magnitude, Epicenter, Peak ground acceleration.

1. Introduction

The earthquake usually caused tremendous damages to human beings and these irreversible damages include loss of human lives, infrastructures, public and private properties, as well as huge adverse economic impacts. Even a relatively moderate earthquake can lead to a very large number of deaths. It is speculated that majority of earthquake related casualties in the past 40 years were caused by the direct effects of ground motion on the built environment (Marano *et al.*, 2010). Damages caused by earthquake are very difficult to be avoided. With the world's population growth concentrated in poorly-constructed urban areas, the global seismic risk is currently increasing (Spence, 2009). Scientists are being paid attention for better understanding of seismic performances which cause the direct damage from ground shaking. Such an assessment may be performed for our country Bangladesh either experimentally or analytically. Peak ground acceleration is considered to be a measure through which ground condition of the earth can be assessed. PGA is defined as the maximum ground acceleration that occurred during earthquake shaking at a location or as the highest amplitude of the absolute acceleration recorded on an accelerogram at a site during a particular earthquake. It is a measure of how hard the earth shakes at a given geographic point. This research work is intended to assess PGA from seismic events which are recorded in many seismological stations owned by various seismological agencies / organizations all over the world. PGA is an important parameter and good determinant for studying the cause

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of damages to construction, building and infrastructure by earthquake. Bangladesh is prone to many kinds of natural disasters such as tropical cyclones with associated storm-surges, floods, droughts, tornadoes and river-bank erosions. The country should also be considered as vulnerable to earthquake. Recent earthquakes adjacent to the country occurred that shaken many areas of the country including capital city Dhaka indicate that Bangladesh stands at an area is not free from earthquake related risk. According to a report published by United Nations IDNDR-RADIUS Initiatives, Dhaka and Tehran are the cities with the highest relative earthquake disaster risk (Cardona *et al.*, 1999). Dhaka, the capital of Bangladesh is the center for economy, commerce, politics and society, with a large population of more or less 12 millions. Once an earthquake of large magnitude occurs in this sub-continent at major cities of Bangladesh such as Dhaka, Chittagong, Cox's Bazar, Sylhet, Mymensingh, Bogra, Rangpur will suffer immense losses of life and property. Unfortunately, it has been not seen any effective measures for studying the vulnerability of new and old constructions in the country. This work is an initiative for studying such vulnerability through the estimation PGA in Bangladesh.

There are many contributions can be seen that have been assessed the PGA over various region of the earth (Milne and Davenport, 1969; Mickey, 1971; Davenport, 1972; Orphal and Lahoud, 1974; Cornell *et al.*, 1979; Espinosa, 1980; Battis, 1981; Hasegawa *et al.*, 1981; Abrahamson and Lithehiser, 1989; Campbell and Bozorgnia, 2008; Mavonga and Durrheim, 2009; Ahulu *et al.*, 2018; etc.). However, it is difficult to accomplish all the requirements to measure PGA for any region over the earth. Based on data and required parameters availability this research work has intended to deal with contributions made by Milne and Davenport (1969), Davenport (1972) and Espinosa (1980) for such PGA assessment through which ground condition of seismically vulnerable area of Bangladesh can be explained.

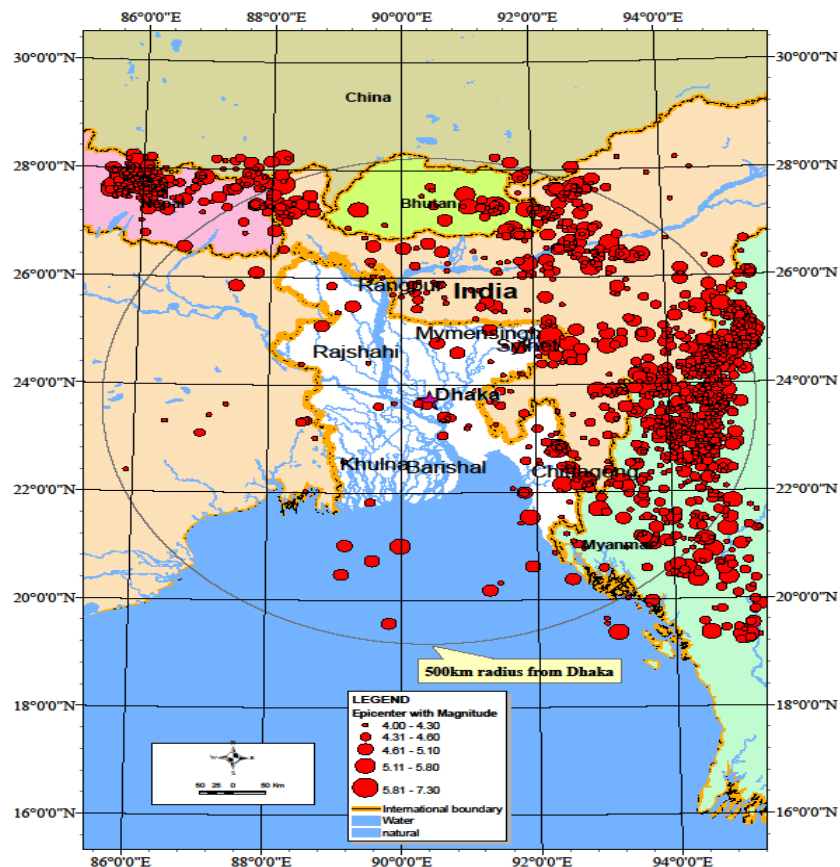


Figure 1. Seismicity map showing epicenters of earthquake data for the duration from 1990 to 2015 for studying the ground condition of Bangladesh.

Earthquake data set of the study area has been incorporated here for studying PGA assessment in Bangladesh for the duration from 1990 to 2015 as shown in Figure 1. Available online data have been compiled from the web site of United States Geological Survey (USGS). Big circle (Figure 1) with a radius of 500 km from the capital city Dhaka indicates the data coverage area. The compiled data along with estimated parameters can be observed in Appendix 1.

2. Methods

In order to assess the ground condition, be obtained from can peak ground acceleration ground motion prediction equations as explained below. Required other parameters such as magnitude conversion and epicentral distance calculation to estimate PGA that different points are also described in the following sections.

2.1. Ground Motion Prediction Equations

To establish the amplitudes of earthquake shock at a specific location due to any given earthquake, it is assumed that for a geographic region (Milne and Davenport 1969),

$$\begin{aligned} \text{Shock amplitude} &= F(\text{magnitude}, \text{epicentral distance}) \\ A &= F(M, \Delta) \end{aligned} \quad (1)$$

where, F is termed as the amplitude distance function and A well-known Richter relationship between earthquake amplitude, magnitude and epicentral distance.

The separation between a point P having latitude and longitude (φ_p, λ_p) and an earthquake epicenter, E (\ddot{o}_E, \ddot{e}_E) is given by

$$\Delta = |P - E| \quad (2)$$

A set of earthquake events of magnitude M_i , having the epicenter $E(\ddot{o}_i, \ddot{e}_i)$ and occurring at time t_i , at a point P a corresponding set of amplitudes A_{P_i} are defined by:

$$A_{P_i} = F(M_i, \Delta_{P_i}) \quad (3)$$

The amplitude distribution can be expressed as followed, if $N(A)$ be the number of shocks occurring per annum in which the shock amplitude exceeds A , then this number is determined by dividing the total number in the set exceeding A by the number of years covered by the set. It is justified in experimental results that $N(A)$ may be expressed by an equation in the form as,

$$N_P(A) = \left(\frac{A}{C_P}\right)^{\dot{a}_P} \quad (4)$$

Or

$$\log_e A = \log_e C_P + \frac{1}{\dot{a}_P} \log_e (N_P(A)) \quad (5)$$

Where C_P and \dot{a}_P are constants, representative of the point P .

If we assume that the occurrence of large earthquakes are independent of one another, and have Poisson's arrivals, then the probability $P_r(A)$ of A being the largest earthquake shock in a year is given by

$$P_r(< A) = e^{-N(A)} \quad (6)$$

Substituting from Eq. 4 the probability distribution of the largest shock amplitude is

$$P_r(< A) = e^{(A/C)^{\dot{a}}} \quad (7)$$

This is in fact the second asymptotic extreme value distribution.

If $V = \log_e A$, $U = \log_e C_P$ and $\dot{a} = -a$

Then

$$P_r(< A) = e^{-e^{-a(V-U)}} \quad (8)$$

Where, U = mode of the distribution and $(1/a)$ = the dispersion of the distribution. The amplitude A having a probability ($P = 1 - P_r$) of being exceeded in any given year is found from:

$$\log_e A = V = U - \frac{1}{a} (\log_e (-\log_e (1 - P))) \quad (9)$$

If A_m is the value of the m th largest amplitude and N is the total number of years of record, plotting

$\log_e A_m$ versus $-\log_e (-\log_e (\frac{m}{N+1}))$ can yield an estimation of the dispersion $1/a$ and U using least squares

fitting. Based on satisfactory result Milne and Davenport (1969) introduced the following amplitude-distance relationship $F(M, A)$, for near field of earthquake energy released,

$$A = F(M, \Delta) = \frac{0.69e^{1.64M}}{1.1e^{1.10M} + \Delta^2} \quad (10)$$

Where, A is the peak acceleration amplitude in cm/sec^2 as a percentage of gravity and Δ is in kilometers. Acceleration in Gal (g) the equation (10) can be further rewritten as:

$$A = 0.0069 \exp(1.64M) / \{1.1 \exp(1.1M) + R_e^2\} \quad (11)$$

Peak ground acceleration in units of g is also given by Davenport (1972) and Espinosa (1980) as shown in the following equations.

$$A = 279 \times 10^{-6} \exp(1.8 * M) / R_e^{1.64} \quad (12)$$

$$A = 1.776 \times 10^{-5} \times \exp(2.3M_l) / R_e^{1.59} \quad (13)$$

2.2. Moment Magnitude Conversion

In many occasions local magnitudes (M_l) are required to convert into moment magnitude (M_w). The earthquake events selected for the present analysis are in local magnitude (M_l). Because of better accuracy the orthogonal regression formula (Araghi 2015) in the following equation preferred to be used as shown has been.

$$M_w = 0.902953(\pm 0.006)M_l + 0.567674(\pm 0.0001) \quad (14)$$

2.3. Epicentral Distance

The distance between earthquake epicenter to the projected point on the surface is known as epicentral distance. The Haversine formula is used to calculate the great-circle distance between two points that is, the shortest distance over the earth's surface (USGS, 2015). The Haversine Formula is given by,

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_1 \cdot \cos\phi_2 \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right) \quad (15)$$

$$c = 2 \cdot \operatorname{atan2}(\sqrt{a}, \sqrt{1-a}) \quad (16)$$

$$d = R \cdot c \quad (17)$$

Where, ϕ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km).

3. PGA Assessment

Earthquake damage potential increases with amplitude however the relation is complex because of the nonlinear inelastic response of sedimentary deposits and structures to damaging levels of motion. Structures, and in some places, sedimentary deposits responding to ground shaking in a resonant manner cause relatively large deformations and stresses to result if the shaking include several cycles of motion with frequencies close to the resonant frequencies of the structure or deposit (Tselentis and Danciu, 2010). The PGA map may help in

this regard as a measure for the construction of new buildings, dams, industry and so on. As intended to develop a PGA map of Bangladesh, the study area has been divided into twelve primary small zones as shown

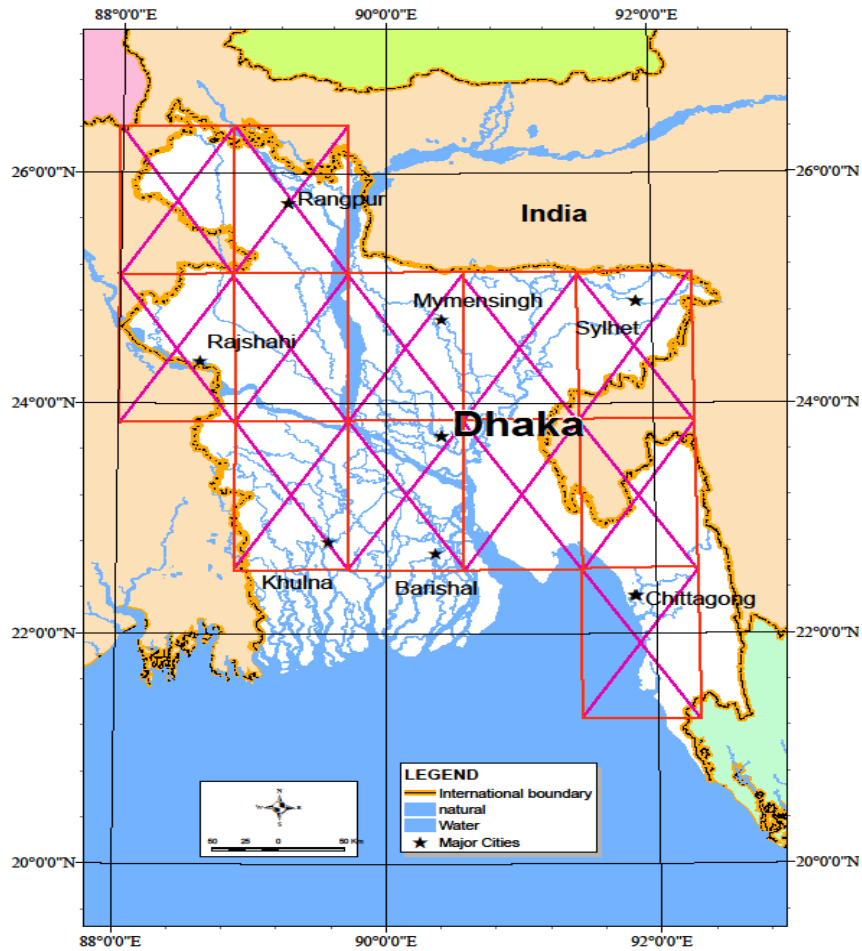


Figure 2. Primary seismic zoning of study area, rectangular box indicate each zone, cross point by diagonal lines is the centre of zone.

in Figure 2 based on apparent investigation of geological, geophysical and geographical information of the study area. From the center of each zone nearest 10 earthquake events were used for the assessment of PGA for each of the zones. Using ground motion equations (Eqs. 11-17) PGA of each zone has been estimated. Earthquake magnitudes for the estimated maximum and minimum PGA are then identified for each zones. Detail can be obtained in Appendix 1 as highlighted for each zone. Estimated PGA distributions for zone 3 and seismic zone map of India (BIS, 2002) have shown in Figure 3 where Figure 3(a) shows seismic zone map of India and Figure 3(b-d) show the PGA distributions estimated by Eqs.11-13 respectively. From the analogy as shown in Figure 3(a-d), estimated PGAs (Figure 3(b-d)) are nearly similar, however, Figure 3b is seemed to be more convincing as PGA has been obtained to be 0.039g, which is equivalent to zone VII of the seismic zone map of India (after BIS, 2002), adjacent to zone 3. Hence, PGA assessment of whole Bangladesh has been carried out accordingly as estimated in Figure 3b using Eq. 11.

Using Eq. 11 earthquake events for maximum and minimum PGA for 12 seismic zones are identified. Then using identified 24 events, PGA distributions have been estimated with 40 m x 40 m grid points for whole Bangladesh and interpolated distributions presented in the form of maps.

4. Estimated PGA Map of Bangladesh

Using 12 earthquake events, as said maximum PGA in 12 zones, maximum PGA at 247 points with regular interval at 40 m x 40 m grid over Bangladesh have estimated and arithmetic average maximum PGA

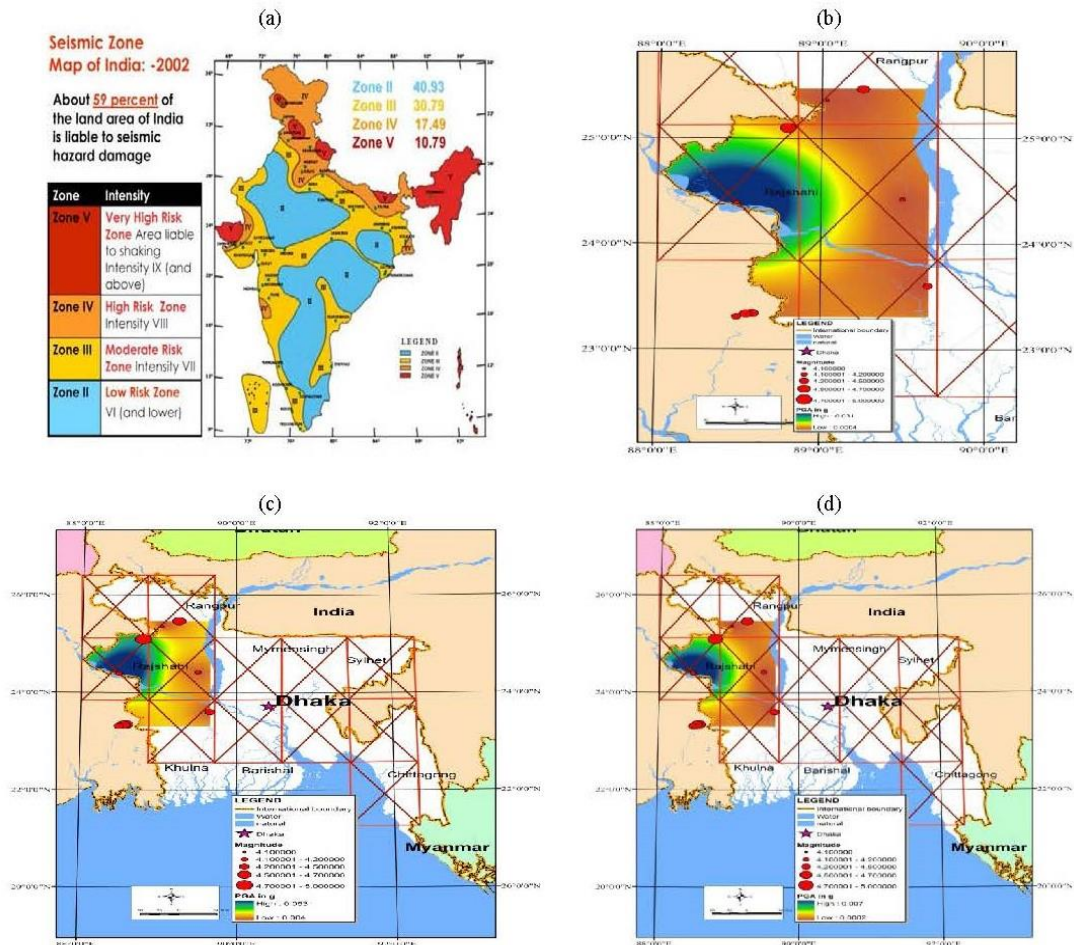


Figure 3. Comparison of PGA value of (a) earthquake zone map of India (after BIS, 2002), (b) estimated using Eq. 11, (c) estimated using Eq. 12 and (d) estimated using Eq. 13 for primary seismic zone 3.

distributions of the 12 zones have shown in Figure 4a. Similarly, using 12 earthquake events average minimum PGA distributions have also estimated and shown in Figure 4b. Root mean square or quadratic mean of maximum and minimum PGA distributions of Bangladesh have also estimated and shown in Figures. 6-7 respectively.

5. Results and Discussion

Earthquake is one of the most frightened natural disasters that can cause severe destruction of properties and lives. PGA, the function of many geological and geophysical parameters is an approach through which ground condition of the earth is to be learned. PGA distribution maps are shown in Figures 4(a-d) 4-7. In addition, cumulative average maximum and minimum PGA distributions not shown here but have estimated for the whole study area in this research work. Where the maximum and minimum PGA distributions were appeared to be 0.034g and 0.023g respectively for most part of the country except a little north-western part of Barisal, Khulna, Rajshahi and Rangpur divisions having lesser values ($<0.023g$), indicate the whole study area are not to be at a vulnerable state, as the higher perceived shaking and damages may belong with PGA value greater than or equal to 0.039g (Wald *et al.*, 1999). However, cumulative maximum PGA distributions of the country indicate as staying just below the threshold level.

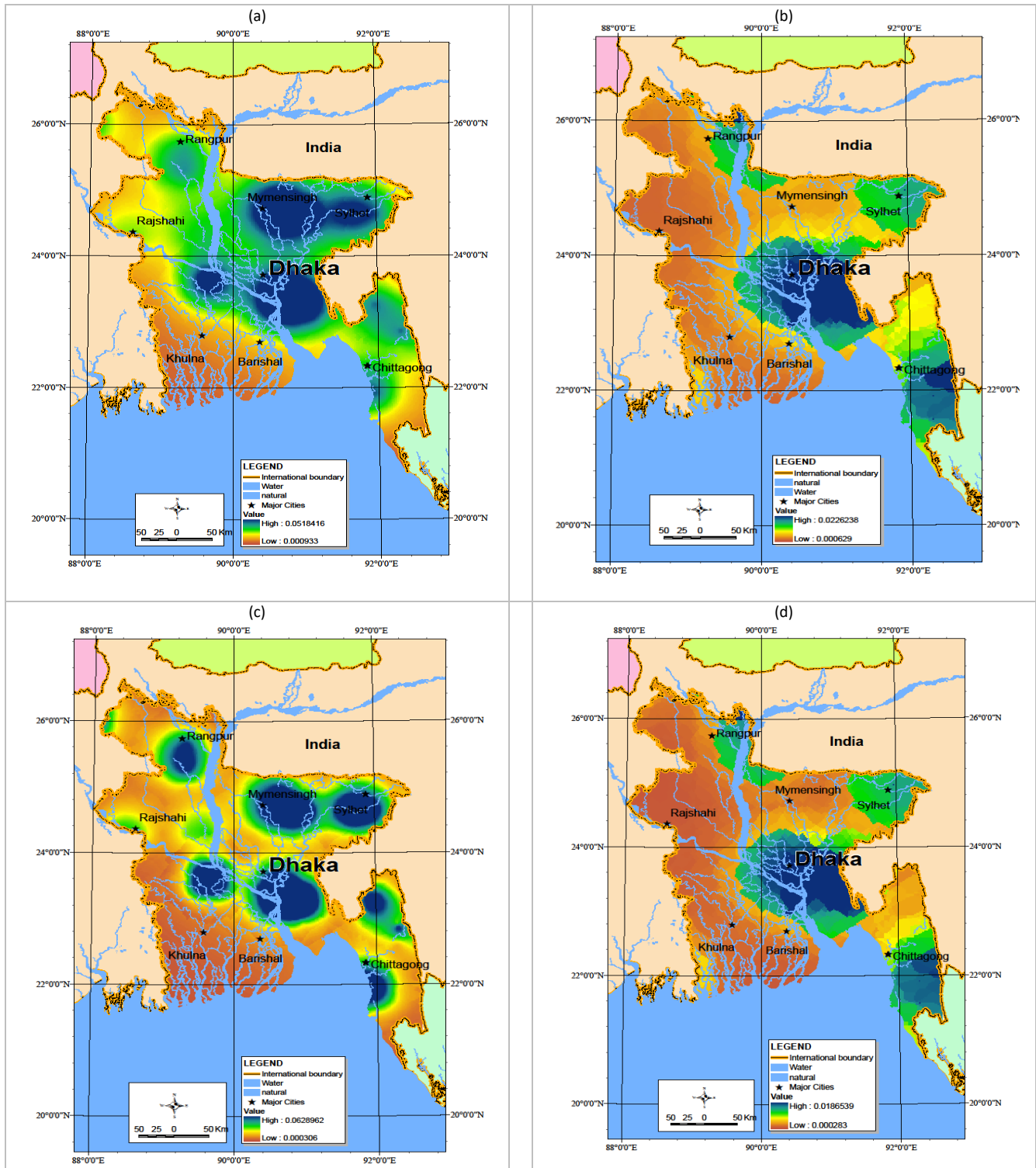


Figure 4. Average (a) maximum PGA and (b) minimum PGA distributions, (c) maximum quadratic mean PGA and (d) minimum quadratic mean PGA distribution maps of whole Bangladesh.

On the other hand, simple or arithmetic mean and quadratic mean of maximum and minimum PGA distributions map as shown in Figures 4a-d are 4-7 have identified different scenario. Estimated simple mean maximum PGA map (Figure 4(a)) has been marked four distinguished points at Mymensingh, Chandpur, Sylhet and north-east part of Khulna as the center of higher PGA with the value of 0.0043g, and minimum PGA map (Figure 4b) has shown that Dhaka and little part of Chittagong as the center of higher PGA value 0.0019g.

However, in maximum PGA distributions (Figure 4a) an average PGA less than but close to 0.0043g are also visible all over the country except major part of Khulna and Barisal divisions along with little part of Rangpur, Rajshahi and Chittagong divisions having PGA value roughly close to 0.00008g. The results have suggested that Mymensingh, Dhaka, Sylhet and north-east part of Khulna have PGA value of 0.0043g which is also less than 0.039g as discussed earlier section.

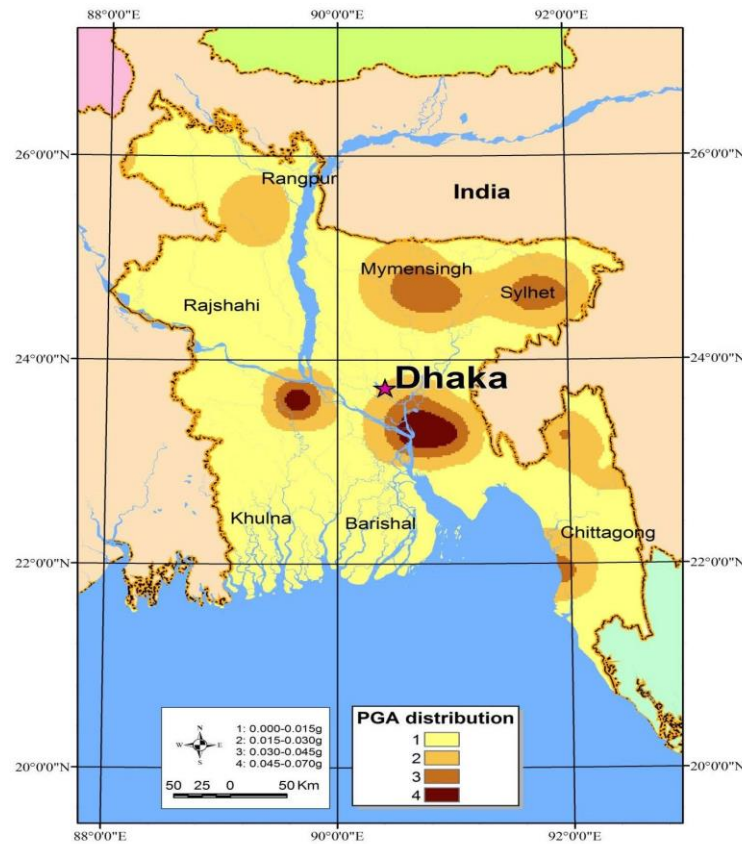


Figure 5. Estimated seismic zone map of Bangladesh according to PGA distributions.

Root mean square or quadratic mean of maximum and minimum PGA distribution maps have shown further different pictures as shown in Figures 4c-d are 6-7. Maximum PGA distributions (Figure 4c) has been marked six locations Chandpur extended upto Dhaka, Mymensingh, Sylhet, Rangpur, north-east part of Khulna and Chittagong as source points for higher PGA with the value of 0.063g. Remaining areas of the country are seemed to be poor PGA value having approximately 0.0003g. While in minimum PGA distribution map, as shown in Figure 4(d), only Dhaka and part of Chittagong have observed the higher PGA with the value of 0.019g. Other areas are seemed to be poor as seen for maximum PGA except Sylhet and Rangpur with a medium value as approximately 0.032g. Once again Chandpur, Mymensingh, Sylhet, Rangpur, north-east part of Khulna and Chittagong are showing greater PGA value of 0.063g (Figure 4c).

From the above findings and observations the work has revealed that major parts of Chandpur, Sylhet and Mymensingh areas are under higher PGA values and fluctuating with a range approximately from 0.02-0.06g. Hence, the areas can be said as of high seismic zone of country. Other areas of the country are seemed to have lower PGA value ranges approximately from 0.0002-0.003g. Based on above understandings, the quadratic mean maximum PGA distributions map has further reformed with four scaled distributions as shown in Figure 5. The map has delineated the seismic zones in Bangladesh.

6. Conclusion

PGA is a measure of earthquake acceleration on ground and an important parameter for seismic hazard assessment as well as earthquake engineering. In some extent it is considered as the design basis for structure. This research work has presented PGA assessment of Bangladesh and described in detail how this assessment has been done. There are many contributions through which PGA can be determined. However, in many occasions it is difficult to assess for the lack of required geophysical and geological parameters. From the point of required variables, this research work has faced various constraints for the development of PGA map. An updated fault map of Bangladesh was to be the prime requirement to accomplish the present work. However, an updated and detailed fault map in Bangladesh is not yet available. Indeed, a fault map contributed by GSB in 2007, has given an effective idea about the fault status of Bangladesh along with other geologic and geographic information to delineate 12 primary seismic zones. As many geological or geophysical parameters were not available, the work was concentrated on how with limited parameters the PGA can be assessed. PGA values are being used to create shake maps by seismologists around the world as PGA value starts to increase from 0.039g or to higher the perceived shaking and damages become high. PGA less than 0.039g of an area can be said that there is no threat for potential damages.

In the presented work it has been observed that PGA distributions, according to cumulative average, are mostly below than the 0.039g. However, the most of the areas have shown with 0.033g which is not so less than 0.039g. From such findings it can be said that Bangladesh is not much under threat by earthquake damages but future developments are to be constructed with more care as it has appeared that the PGA value is just less than the threshold.

However, the simple and quadratic average PGA distributions have presented the different pictures of the country. From such PGA distributions, it has revealed that eight locations at Chanpur extended upto Dhaka, Mymensingh, Sylhet, Rangpur, part of Chittagong and the north-east region of Khulna divisions of the country have attained PGA value of 0.063g which indicates a light to moderate threat for potential damages. From an analogy with seismic zone map of India and the fault map published by GSB, PGA distributions assessed in this work are found to be well agreed as fault zones are crucial for potential damages. Finally, this work has also presented a seismic zone map according to estimated PGA distributions. Presented PGA maps may be useful as valuable aids for the planners, engineers and geoscientists for the enhancement of the development process of Bangladesh for new installments and seismic designs.

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Appendix 1

Seismic Zone	Zone Center		Earthquake Event				Moment Magnitude M_w	Epicentral Distance R_e	PGA	Remarks
	Lon	Lat	Longitude	Latitude	Depth	Local Magnitude M_L				
Zone 1	88.43	25.77	88.791	25.009	33	5	5.08244	92.0625	0.00328	
	88.43	25.77	89.03	26.36	11.8	4.1	4.26978	88.858	0.00095	
	88.43	25.77	89.252	25.468	33	4.7	4.81155	88.9949	0.00227	
	88.43	25.77	88.932	25.842	39.8	4.5	4.63096	50.8868	0.00495	
	88.43	25.77	89.5651	26.0259	8.4	4.2	4.36008	117.053	0.00064	
	88.43	25.77	88.199	26.51	33	4.6	4.72126	85.4541	0.00212	
	88.43	25.77	88.055	26.8644	31.71	5.1	5.17273	127.302	0.00202	
	88.43	25.77	87.593	26.817	33	4.3	4.45037	143.234	0.00049	Min
	88.43	25.77	87.777	26.087	28.8	5	5.08244	74.2073	0.00496	Max
	88.43	25.77	87.473	25.85	29.7	5	5.08244	96.2099	0.00301	
Zone 2	89.29	25.77	88.791	25.009	33	5	5.08244	98.3519	0.00289	
	89.29	25.77	89.03	26.36	11.8	4.1	4.26978	70.5582	0.00149	
	89.29	25.77	89.252	25.468	33	4.7	4.81155	33.7963	0.01355	Max
	89.29	25.77	88.932	25.842	39.8	4.5	4.63096	36.7212	0.00898	
	89.29	25.77	89.9947	25.6224	15	4.1	4.26978	71.8016	0.00144	
	89.29	25.77	89.86	25.686	19.6	4.1	4.26978	57.8567	0.00219	
	89.29	25.77	89.7033	26.0035	16.03	4.3	4.45037	48.8219	0.00403	
	89.29	25.77	89.6651	26.6269	8.4	4.2	4.36008	102.369	0.00083	Min
	89.29	25.77	89.5355	26.236	14.91	4	4.17949	57.3319	0.00193	
	89.29	25.77	89.521	26.301	10	4.5	4.63096	63.3949	0.00327	
Zone 3	88.43	24.49	88.481	24.39	35	4.2	4.36008	12.2596	0.03103	Max
	88.43	24.49	88.791	25.099	33	5	5.08244	76.9	0.00463	
	88.43	24.49	89.03	25.36	11.8	4.1	4.26978	114.101	0.00058	
	88.43	24.49	89.252	25.468	33	4.7	4.81155	136.713	0.00098	
	88.43	24.49	89.4984	24.4221	14.43	4.2	4.36008	108.405	0.00074	
	88.43	24.49	89.655	23.602	35	4.4	4.54067	158.817	0.00047	
	88.43	24.49	88.586	23.342	36.4	4.6	4.72126	128.633	0.00095	
	88.43	24.49	88.547	23.337	33	4.6	4.72126	128.758	0.00095	
	88.43	24.49	88.49	23.3104	35.88	4.5	4.63096	131.307	0.00079	
	88.43	24.49	87.36	23.636	10	4.2	4.36008	144.29	0.00042	Min
Zone 4	89.29	24.49	88.481	24.39	35	4.2	4.36008	82.6474	0.00126	
	89.29	24.49	88.791	25.099	33	5	5.08244	84.3974	0.00388	
	89.29	24.49	89.03	25.36	11.8	4.1	4.26978	100.229	0.00075	
	89.29	24.49	89.252	25.468	33	4.7	4.81155	108.816	0.00153	
	89.29	24.49	90.23	25.419	33	4.5	4.63096	140.182	0.00069	
	89.29	24.49	90.376	23.632	10	4.5	4.63096	145.809	0.00064	Min
	89.29	24.49	90.259	23.662	44	4.5	4.63096	134.737	0.00075	
	89.29	24.49	89.885	23.662	10	4.2	4.36008	110.116	0.00072	
	89.29	24.49	89.655	23.602	35	4.4	4.54067	105.468	0.00105	
	89.29	24.49	89.4984	24.4221	14.43	4.2	4.36008	22.4044	0.01383	Max
Zone 5	90.15	24.49	89.4984	24.4221	14.43	4.2	4.36008	66.3846	0.00194	
	90.15	24.49	89.655	23.602	35	4.4	4.54067	110.798	0.00095	
	90.15	24.49	89.885	23.662	10	4.2	4.36008	95.9194	0.00094	
	90.15	24.49	90.259	23.662	44	4.5	4.63096	92.732	0.00156	
	90.15	24.49	90.376	23.632	10	4.5	4.63096	98.1259	0.0014	
	90.15	24.49	90.837	24.608	33	4.7	4.81155	70.7135	0.00353	
	90.15	24.49	90.3369	24.788	17.5	4.8	4.90185	51.2557	0.00746	Max
	90.15	24.49	90.23	25.419	33	4.5	4.63096	103.614	0.00126	
	90.15	24.49	90.25	25.596	26.7	4.4	4.54067	123.393	0.00077	
	90.15	24.49	89.9947	25.6524	15	4.1	4.26978	130.196	0.00044	Min
Zone 6	91	24.5	90.53	24.788	17.5	4.8	4.90185	57.2881	0.00607	
	91	24.5	90.837	24.608	33	4.7	4.81155	20.396	0.02906	Max
	91	24.5	91.345	24.44	33	4	4.17949	35.5482	0.00476	
	91	24.5	91.5293	24.1878	31.79	4.1	4.26978	63.8787	0.00181	
	91	24.5	91.563	24.735	39.4	4.1	4.26978	62.6248	0.00188	
	91	24.5	91.33	25.03	33	4.7	4.81155	67.7002	0.00384	
	91	24.5	91.13	25.241	40	4.3	4.45037	83.4326	0.00143	
	91	24.5	91.208	25.455	45.1	4.5	4.63096	108.241	0.00115	
	91	24.5	91.426	26.376	37.5	4.2	4.36008	212.942	0.00019	Min
	91	24.5	91.553	25.371	24.9	4.2	4.36008	111.754	0.0007	

Seismic Zone	Zone Center		Earthquake Event				Moment Magnitude M_w	Epicentral Distance R_e	PGA	Remarks
	Lon	Lat	Longitude	Latitude	Depth	Local Magnitude M_L				
Zone 7	91.86	24.5	91.5253	24.1878	31.79	4.1	4.26978	48.5271	0.00306	
	91.86	24.5	91.782	24.209	22.5	4.3	4.45037	33.3085	0.00812	
	91.86	24.5	91.815	24.206	20	4	4.17949	33.0076	0.00546	
	91.86	24.5	92.109	24.391	33	4.6	4.72126	27.9681	0.01622	
	91.86	24.5	92.072	24.532	43.7	4	4.17949	21.7412	0.01124	
	91.86	24.5	92.143	24.742	38.7	4.2	4.36008	39.2743	0.00525	
	91.86	24.5	91.966	24.998	41.7	4	4.17949	56.4001	0.00199	Min
	91.86	24.5	91.563	24.735	39.4	4.1	4.26978	39.8021	0.00445	
	91.86	24.5	91.772	24.692	33	4.9	4.99214	23.1292	0.03093	Max
	91.86	24.5	91.863	24.714	56.6	4.2	4.36008	23.7976	0.01258	
Zone 8	89.3	23.2	88.572	22.02	10	4.1	4.26978	150.997	0.00033	Min
	89.3	23.2	89.146	22.576	10	4.3	4.45037	71.1564	0.00196	
	89.3	23.2	90.376	23.632	10	4.5	4.63096	119.84	0.00094	
	89.3	23.2	90.259	23.662	44	4.5	4.63096	110.509	0.00111	
	89.3	23.2	89.885	23.662	10	4.2	4.36008	78.7487	0.00139	
	89.3	23.2	89.655	23.602	35	4.4	4.54067	57.5372	0.00341	Max
	89.3	23.2	88.586	23.242	36.4	4.6	4.72126	73.1108	0.00287	
	89.3	23.2	88.547	23.337	33	4.6	4.72126	78.4134	0.00251	
	89.3	23.2	88.4902	23.3104	35.88	4.5	4.63096	83.6356	0.00191	
	89.3	23.2	88.706	23.011	35	4.2	4.36008	64.2838	0.00206	
Zone 9	90.17	23.2	89.655	23.602	35	4.4	4.54067	68.9938	0.0024	
	90.17	23.2	89.885	23.662	10	4.2	4.36008	59.0303	0.00243	
	90.17	23.2	90.259	23.662	44	4.5	4.63096	52.1684	0.00473	
	90.17	23.2	90.376	23.632	10	4.5	4.63096	52.4338	0.00468	
	90.17	23.2	90.648	23.394	10	5.1	5.17273	53.3713	0.01051	Max
	90.17	23.2	90.691	23.398	10	4.2	4.36008	57.5834	0.00255	
	90.17	23.2	90.732	23.407	10	4.5	4.63096	61.837	0.00343	
	90.17	23.2	90.63	23.355	10	4.2	4.36008	50.0475	0.00333	
	90.17	23.2	90.611	23.063	42.5	4.5	4.63096	47.5982	0.00561	
	90.17	23.2	90.998	23.248	10	4.1	4.26978	84.7771	0.00104	Min
Zone 10	91.01	23.2	91.521	23.686	10	4	4.17949	62.6658	0.00162	Min
	91.01	23.2	91.4071	23.6717	38	4.1	4.26978	66.2748	0.00168	
	91.01	23.2	91.406	23.237	38.1	4	4.17949	40.6755	0.00371	
	91.01	23.2	90.998	23.248	10	4.1	4.26978	5.4764	0.05039	Max
	91.01	23.2	90.979	23.3	33	4.1	4.26978	11.5617	0.02984	
	91.01	23.2	90.732	23.398	10	4.5	4.63096	35.9277	0.00933	
	91.01	23.2	90.691	23.394	10	4.2	4.36008	39.0735	0.0053	
	91.01	23.2	90.648	23.407	10	5.1	5.17273	43.5487	0.01501	
	91.01	23.2	90.63	23.355	10	4.2	4.36008	42.4691	0.00434	
	91.01	23.2	90.611	23.063	42.5	4.5	4.63096	43.5311	0.00661	
Zone 11	91.88	23.2	91.834	23.472	27.8	4.6	4.72126	30.6075	0.01401	
	91.88	23.2	91.406	23.273	38.1	4	4.17949	49.1066	0.0026	
	91.88	23.2	91.847	22.59	33	4.5	4.63096	67.9131	0.00286	
	91.88	23.2	92.035	22.501	10	4.2	4.36008	79.3314	0.00137	
	91.88	23.2	92.168	22.743	10	4.3	4.45037	58.7504	0.00283	
	91.88	23.2	92.157	22.936	10	4.6	4.72126	40.8019	0.00854	
	91.88	23.2	92.235	22.06	10	4.2	4.36008	131.894	0.0005	Min
	91.88	23.2	92.024	23.164	33	4.5	4.63096	15.2539	0.03329	Max
	91.88	23.2	91.89	22.848	33	4.1	4.26978	39.154	0.00459	
	91.88	23.2	92.255	22.765	36.9	4.8	4.90185	61.7518	0.00527	
Zone 12	91.88	21.92	92.006	22.544	10	4.3	4.45037	71.8165	0.00192	
	91.88	21.92	91.651	22.074	33	4.1	4.26978	29.1661	0.00781	
	91.88	21.92	91.822	21.998	17.3	4.6	4.72126	10.5357	0.05146	
	91.88	21.92	91.811	21.999	10	4.9	4.99214	11.3649	0.06284	Max
	91.88	21.92	91.895	21.544	10	5.2	5.26303	41.838	0.01833	
	91.88	21.92	91.762	21.431	33	4.3	4.45037	55.7247	0.00314	
	91.88	21.92	92.36	21.538	33	4	4.17949	65.288	0.0015	Min
	91.88	21.92	92.485	21.817	33	4.1	4.26978	63.4738	0.00183	
	91.88	21.92	92.343	22.037	33	4.2	4.36008	49.4825	0.00341	
	91.88	21.92	92.388	22.15	28.7	5.5	5.53302	58.7230	0.01554	

DEGRADATION OF ENVIRONMENTALLY TOXIC CADMIUM USING BACTERIA ISOLATED FROM SOIL IN BSCIC AREA, RAJSHAHI

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Abstract

Cadmium (Cd) is a silvery-white, lustrous but tarnishable metal and poisonous for plants, animals and humans. In this study, cadmium degrading bacterial strains were isolated from the soil samples obtained from BSCIC area, Rajshahi. Isolate A (cream colored) showed highest growth at pH 7.5 and at temperature 37°C while isolate B (yellow colored) showed highest growth at pH 7.2 and at temperature 35°C after 72 hours of incubation period. Peptone was proved as the best carbon source for both bacterial strains. Biochemically, non-lactose fermenting and methyl red positive but isolate B was gram negative, round shaped, lactose fermenting and methyl red negative and both isolates were acid producing, non-motile, citrate and catalase test positive. Among all of the used antibiotics, chloramphenicol, vancomycin, gentamycin and ciprofloxacin were observed as more efficient antibiotic agents against both of these isolates compare to amoxicillin, penicillin and erythromycin. The toxicity of Cd was observed on mitotic cell division of *Allium cepa*. After treatment with cadmium (100 µM), abnormal mitosis was detected indicating asymmetrical position and number of chromosomes with unusual and degenerating nucleus. Moreover, nucleus disruption and sticky metaphase were also found after the treatment of 50 µM cadmium. Cd tolerance and reducing capability of both the isolates were investigated. Both isolates showed the ability to degrade Cd ranges from 0.01 gm/100 ml to 0.04 gm/100 ml after 96 hours of incubation period and the MIC values of Cd was 0.4 mM. The isolated two bacterial strains could be used in bioremediation processes to detoxify cadmium from polluted environments.

Keywords: Cadmium (Cd), Industries toxicity, Minimum Inhibitory Concentration (MIC), Environmental pollution.

1. Introduction

Heavy metals pollution is now a growing concern worldwide especially in developing countries (Silambarasan *et al.*, 2012). Most of the industries in Bangladesh dispose different types of heavy metals in the environment without proper treatment and pollute the environment severely. Industrial zone (BSCIC area, Rajshahi) also disposes various heavy metals to the environment. Especially, excessive level of cadmium in soil was detected in Rajshahi BSCIC area by the laboratory experiments. Heavy metals are recognized as powerful inhibitors of biodegradation activities. Heavy metals occur naturally in the ecosystem with large variations in concentration. Cadmium is one of the most hazardous pollutant heavy metal and non-essential but poisonous for plants, animals and humans (Gupta and Gupta, 1998). Toxic cadmium is found in effluents and discharged wastewater of industries like electroplating, steel, alloy, motor vehicles, aircraft, paint, chemical, textile, pigment etc. (Sani *et al.*, 2001; Saithong and Poonsuk, 2002). The acute oral lethal dose of cadmium for humans has not been established; it has been estimated to be several hundred milligrams. Generally safe daily levels of Cd intake should be kept below 30 microgram per person.

Inhaling cadmium-laden dust quickly leads to respiratory tract and kidney problems which can be fatal (often from renal failure). Ingestion of any significant amount of cadmium causes immediate poisoning and damage to

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the liver and the kidneys. If we can find out the bacteria capable of reducing cadmium from the soil, it will obviously help the plant material to grow in normal mode. Undoubtedly, it will also be helpful to reduce cadmium toxicity from the different components of the environment. The present research work deals with the morphological, physiological and biochemical characterizations of the isolated bacteria, antibiotic sensitivity test and cytogenetic effect of cadmium on mitotic cell division of plant. Finally, the efficiency of cadmium degradation was observed and minimum inhibitory concentration (MIC) was also determined against the isolated bacterial strains.

2. Materials and Methods

The soil samples were collected from the sewage of Bangladesh Small and Cottage Industries Corporation (BSCIC) industrial zone, Sopura, Rajshahi, Bangladesh. The samples were collected in sterile plastic container and transported to laboratory for bacteriological analysis. Then the sewage water filtered by filter paper in a beaker and mixed bacterial cultures. Cadmium was collected as $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ from the department of Chemistry, University of Rajshahi, Bangladesh. The cadmium was collected in glassware container and stored until use.

The mixed bacterial cultures were grown in MS medium at different concentration of cadmium. Then the bacterial isolates were screened on nutrient agar (NA) plates supplemented with peptone 1 gm/100 ml, yeast extract 0.5 gm/100 ml and agar 2 gm/100 ml. The growth and morphological characteristics of both strains were observed in LB (Lauria Bertani) and MS (Minimal Salt) media by standard plating and streaking techniques were incubated at 37°C for 24h. Then the bacterial strains will be isolated and suspended in LB liquid medium for storage and further uses.

Colonial morphology such as shape, color, opacity and consistency appearance on the LB media will be recorded. Gram staining, motility test and viable cell counting will be conducted. Methyl red, catalase, macConkey, citrate utilization and SIM-medium (Sulphide-Indole-Motility medium) tests will be performed to characterize the isolates.

Effects of pH variations, temperatures and carbon sources on growth were performed to study the stability of the isolates for the biodegradation of cadmium and these experiments were conducted in a Erlenmeyer flask containing 10 µg/ml of the two isolated bacterial cultures were inoculated in 100 ml Minimal salt broth. After sterilization by autoclaving the flasks were cooled and inoculated with the bacterial cultures and maintained at different temperatures ranging from 10°C to 50°C for the test of temperature effects; maintained at different pH ranging from 0 to 10 for checking the pH effects; added 1g of various carbon sources (glucose, sucrose, peptone and glycerol) for examining the effects of carbon sources of the bacterial isolate. After inoculation the cultural flasks were placed on orbital shaker at 150 rpm for 96 hours to observe their growth efficiency. The bacterial growth was measured by observing the optical density (OD) at 660 nm through UV-spectrophotometer (ANALYTIK JENA AG, SPOKOL 1500/1, GERMANY) after different time intervals.

The antibiotic sensitivity testing of the isolates were performed against seven antibiotics following the disk diffusion method (Bauer *et al.*, 1966). The test material used is onion bulbs from a population of commercial varieties of *Allium cepa*. This species has somatically 16 large chromosomes ($2n=16$) with clear and characteristic morphologic features, suitable for rapid mitotic studies. Cytological study was carried out with the collected root tips using both control and treatment (Cd) medium roots were collected by a pair of fine forceps and fixed in aceto-alcohol (1:3) solution. After 24 hours of fixation, root tips were transferred from fixative to 70% ethanol and stored in the refrigerator until they were used in the laboratory.

A compound microscope was used for microscopic analysis. All the cells were observed in 40X magnification in the microscope (LABOMED Cx1). Cell counts were carried out considering visual fields scanning the whole slide. During the cell count, the cells were divided into two categories: regular (do not present damages in the chromosomes)

and irregular (present damages in the chromosome, such as: chromosomal breakages, simple or multiple anaphasic bridges, laggard or lost chromosome, sticky metaphase etc.).

Different mitotic abnormalities such as bridge, fragments, laggard, stickiness etc. were observed and the percentage of mitotic abnormalities were calculated by following formula,

Percentage of mitotic abnormalities = $\frac{\text{Error!}}{\text{Total}} \times 100$

In case of two isolated bacterial strains (isolate A and isolate B), the MIC value was determined by broth tube dilution method against heavy metals (Cd). Based on the evaluation, minimum inhibitory concentration was determined at 37 °C after 24 hours of incubation period. The lowest concentration that prevented bacterial growth was considered the MIC.

Cadmium degradation efficiency of both isolated bacterial strains observed in MS media. Isolates were grown in different 100ml shake flasks containing 40 ml of cadmium supplemented medium (0.01 g, 0.02 g, 0.03 g, 0.04 g, 0.05 g and 0.06 g Cd) inoculated with 0.5 ml of cells (1% inoculum). Flasks were incubated at 30°C and agitated at 200 rpm in a shaker bath. Optical density at 660 nm (OD₆₆₀) and pH were monitored. Selected samples were transferred to eppendorf tubes and centrifuged for 5 min at 8000 x g. The supernatant was drawn and stored at 20°C for cadmium analysis. The cadmium concentration in the supernatant was determined with an Analytik Jena, spekol 1500 UV-visible spectrometer at 228.8 nm with a cadmium lamp.

3. Results

3.1. Isolation of Cadmium Degrading Bacteria

Two pure bacterial strains isolate A (cream colored) and isolate B (yellow colored) were isolated in LB and MS media as mixed bacterial culture from the soil samples collected from BSCIC industrial zone, Sopura, Rajshahi. The isolates showed the ability to grow in the presence of cadmium and stored in LB liquid medium for further studies.

3.2. Characterization of Isolated Bacteria

The colony characteristics (colony shape, color, opacity and consistency) of the isolated bacterium were noted after the growth at 37°C under the light microscope. The morphological (gram staining, motility test and viable cell counting) and biochemical (methyl red, catalase, macConkey, citrate utilization and SIM-medium) characterization was carried out according to standard methods (Collins *et al.*, 1985) (Table 1). The physiological characterizations (pH, temperature, carbon sources) were done at 660 nm OD to optimize the culture conditions. For isolate A showed highest growth at pH 7.5 and temperature 37°C while for isolate B at pH 7.2 and temperature 35°C after 72 hours of incubation period. Among different carbon sources used in the study, peptone was proved as the best carbon source for both bacterial strains.

3.3. Antibiotic Sensitivity Test

Antibiotic sensitivity test of both isolated bacteria were done against seven antibiotics. Among the seven antibiotics, isolate A was susceptible to chloramphenicol, vancomycin, gentamycin and ciprofloxacin but intermediate resistant to erythromycin and resistant to penicillin and amoxicillin. Isolate B was susceptible to chloramphenicol, erythromycin, gentamycin, ciprofloxacin and amoxicillin but resistant to penicillin and vancomycin. The result showed that chloramphenicol, vancomycin, gentamycin, ciprofloxacin were more efficient antibiotic agent against both of these isolate compare to amoxicillin, penicillin and erythromycin (Table 2).

Table 1. The summarized results of morphological and biochemical tests

No.	Test Name	Results	
		Isolate A	Isolate B
01	Colonial morphology such as shape, color, opacity and consistency	Round, cream, translucent and sticky	Round, yellow, hazy and Sticky
02	Gram test	Gram positive	Gram negative
03	Motility test	–	–
04	Viable cellcounting	3.13×10^{10} cells/ μ l	3.74×10^{15} cells/ μ l
05	SIM-medium test	Indole +	Indole +
06	Methyl Red test	+	–
07	Citrate test	–	–
08	Catalase test	+	+
09	MacConky Test	+	–

The (+) signs indicates positive results and (–) signs indicates negative results.

Table 2. Antibiotic sensitivity test of the isolated bacteria

Name of Antibiotic	Disk Potency	Inhibition zone (mm)		Response	
		Isolate A	Isolate B	Isolate A	Isolate B
Amoxicillin	10mcg	2mm	19mm	Resistant	Susceptible
Chloramphenicol	30mcg	24mm	28mm	Susceptible	Susceptible
Ciprofloxacin	5 μ g	26mm	24mm	Susceptible	Susceptible
Erythromycin	15 μ g	15mm	30mm	Intermediate resistant	Susceptible
Gentamycin	10mcg	27mm	20mm	Susceptible	Susceptible
Penicillin	10 units	0mm	0mm	Resistant	Resistant
Vancomycin	30mcg	8mm	9mm	Resistant	Resistant

Antibiotic sensitivity range: resistant= \leq 10 mm, intermediate =10-15 mm, susceptible= \geq 15 mm.

3.4. Toxicity of Cadmium on Mitotic Cell Division of *Allium cepa*

Cytogenetic study showed the toxic effect of cadmium on mitosis cell division of *Allium cepa* where different chromosomal aberration and abnormal distribution of chromosomes were found. Result indicated that cadmium have adverse effect on cell division as abnormal cell division phenomena were observed during the study under light microscope. In normal prophase, metaphase, anaphase and telophase stage showed the chromatin shortens and thickens into double stranded chromosomes and the nuclear membrane disintegrates, the spindle fibers line up the double stranded chromosomes in the equator of the cell, the spindle fibers pull on the centromeres of the chromosomes separating the sister chromatids of each double stranded chromosome and the chromatids reach the opposite poles of the cell and the spindle detaches and new nuclear membranes form around the chromatids (Figures 1 A, B, C and D).

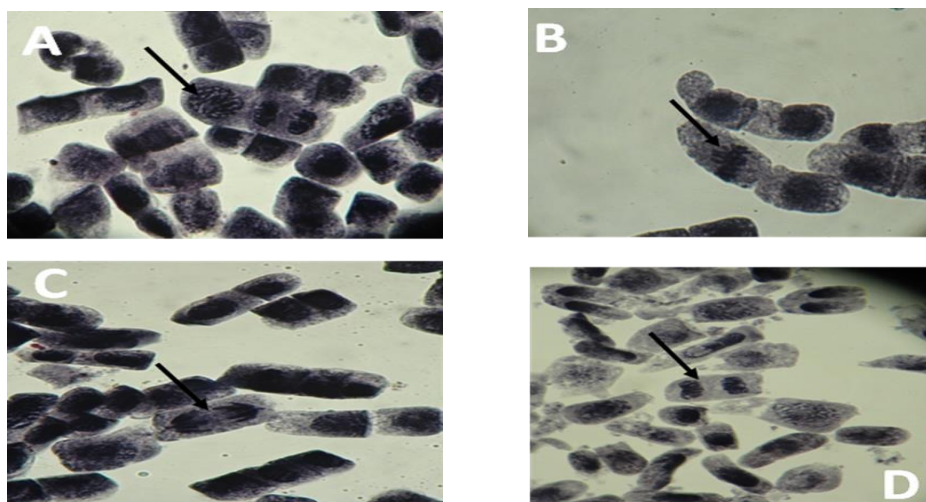


Figure 1. Mitotic cell division in control medium- A) normal prophase, B) normal metaphase, C) normal anaphase, D) normal telophase.

In mitosis cell division abnormal position and number of chromosome were observed and chromosomes take abnormal position dissimilar to normal phases while the abnormal and degenerating nucleus indicate the toxicity of cadmium (Figures 2. A and B).

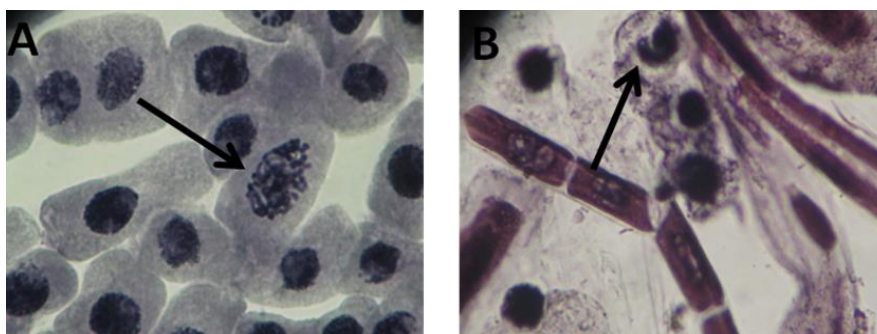


Figure 2. Abnormal mitosis at 100 μ M cadmium, A) abnormal position and number of chromosomes, B) abnormal and degenerating nucleus.

Chromosome bridges and / or fragments result from chromosome and chromatid- breaks and sticky chromosomes indicate highly toxic, usually irreversible effect probably leading to cell death (Figure 3. A, B).

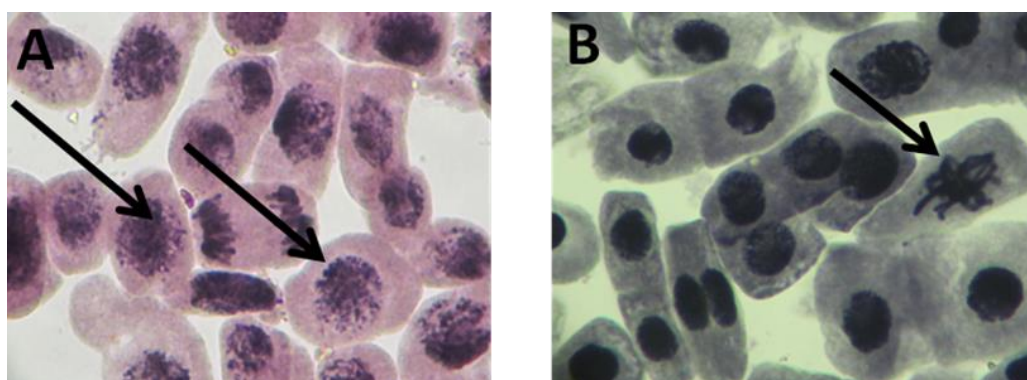


Figure 3. Effect of 50 μ M treatment of cadmium on mitosis: A) nucleus disruption. B) sticky metaphase.

3.5. Cadmium Tolerance and Reducing capability of Isolated Bacteria

3.5.1. Determination of MIC of Cadmium

Two isolated bacterial strains (isolate A and isolate B) were used to observe the capability of heavy metal (Cd) tolerance. MIC was determined by the tube dilution method against respective heavy metal (Cd) by gradually increasing the concentration of Cd in test tube containing LB medium until the bacterial strains failed to grow. The initial metal concentration used 0.5 mM was prepared from 1 M stock solution. Different volume of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ solution from the 0.5 mM stock solution were taken and added to LB medium containing 1ml liquid bacterial culture in test tubes. The stock solution of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ was prepared in sterile deionized water and sterilized by autoclaving at 121°C for 20 minutes. The final volume was adjusted to 100 ml each time. The initial concentration used was 0.1 mM $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ solution/100 ml. Different concentration used were 0.2 mM, 0.24 mM, 0.3 mM, 0.4 mM, 0.5 mM, and 0.6 mM. The growth of cultures was measured by spectrophotometer at 660 nm. The MIC of cadmium for both isolates (A and B) was 0.4 mM (Figure 4).

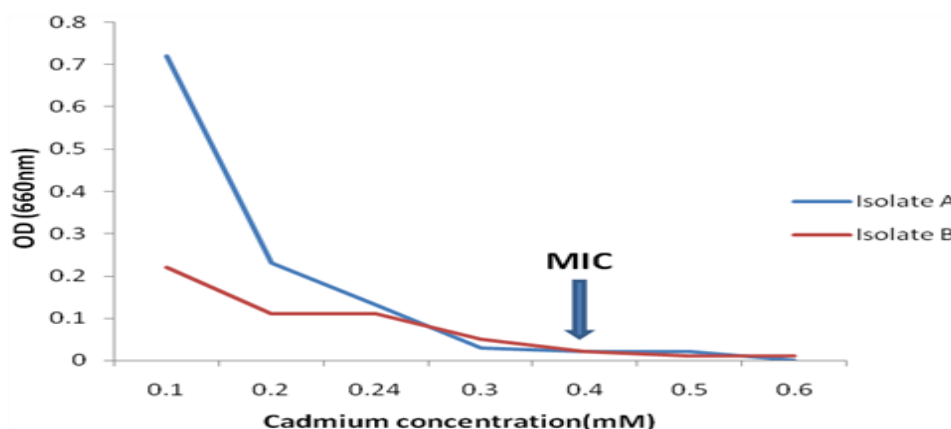


Figure 4. MIC of cadmium against both isolates.

3.5.2. Degradation of Cadmium

Study indicated that isolate A had more ability to degrade cadmium than isolate B. Both isolates A and isolate B can degrade cadmium from 0.01 gm/100 ml to 0.04 gm/100 ml after 96 hours of incubation period but isolate A is more efficient and take less time to degrade cadmium comparing with isolate B (Figures 5 and 6).

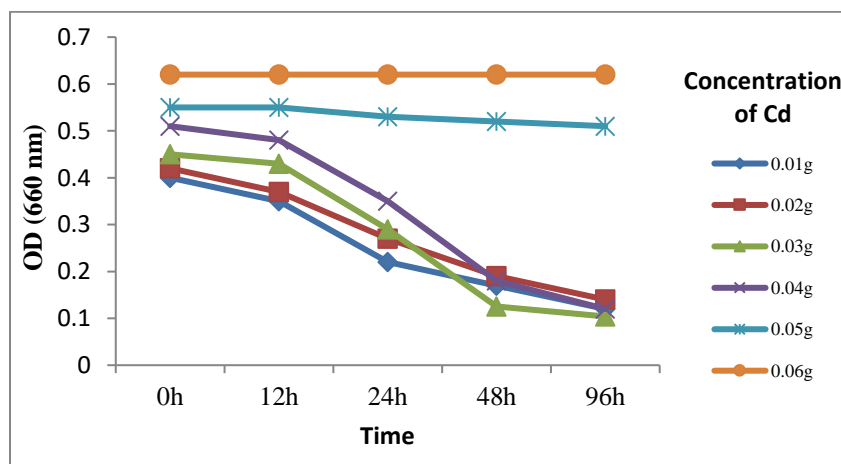


Figure 5. Absorbance (OD_{228.8nm}) of cadmium with cadmium degrading bacteria (isolate A) at different time intervals.

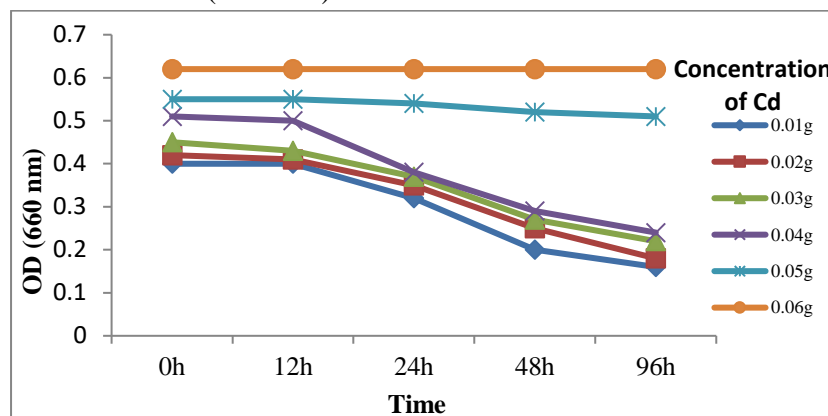


Figure 6. Absorbance (OD_{228.8nm}) of cadmium with cadmium degrading bacteria (isolate B) at different time intervals.

4. Discussion

The presence of cadmium in soils, sediments and water is a major environmental concern. It releases into the environment in large amounts as an industrial waste has led to its current ranking as a major anthropogenic pollutant (Cunningham and Lundie, 1993). According to all of the morphological and biochemical test results, the biochemical characteristics and nature of the isolates are partially similar with Soumitra Nath *et al.* (2012). The lactose fermenting capability of two strains was also detected from the mac Conkey agar test indicating lactose non-fermenting for strain A and lactose fermenting for strain B. In antibiotic sensitivity test, isolate A was found susceptible to chloramphenicol, vancomycin, gentamycin and ciprofloxacin while it was intermediate resistant to erythromycin but resistant to penicillin and amoxicillin. On the other hand, isolate B was found to be susceptible to amoxycillin, chloramphenicol, gentamycin, ciprofloxacin and erythromycin but resistant to penicillin and vancomycin. Cd⁺² resistant gram-negative non-fermentative strains (GNNFR) and gram-positive cocci were isolated by Katarina *et al.*, (2004). So the present study is in agreement with the findings of Soumitra Nath *et al.*, (2012).

Cd is a particularly dangerous pollutant due to its high toxicity and great solubility in water (Duxbury *et al.*, 1985). At low concentrations, Cd is not toxic to plants but at higher concentrations it is toxic. Characteristically Cd inhibits root growth and cell division in plants such as onion, tradescantia, *Vicia faba* (Steinkellner *et al.*, 1998), *Nicotianatabacum* (Fojtová *et al.*, 2000) and *Allium sativum* (Yi and Meng, 2003). Cadmium induced chromosomal aberrations in root tip cells of *A. cepa* with vagrant chromosomes, bridges and fragments and sticky chromosomes being most frequently observed. This suggests the presence of certain genotoxic substances in those industrial effluents. Similarly, It is well documented that Cd exposure, can cause growth inhibition related to reduction of mitotic activity, induction of chromosome disorders and nuclear abnormalities in the apical meristems (Liu *et al.*, 2004; Zhang *et al.*, 2009 and Qin *et al.*, 2010). So the present study is in agreement with the findings of Liu *et al.* (2004) and Zhang *et al.* (2009). Cd was found to induce chromosomal aberrations, micronucleus (MN) formation in plant root cells (Zhang and Yang, 1994). This is also in agreement with the findings of Shuhai Xiao *et al.* (1998). Vagrant chromosomes have been described as a weak c-mitotic effect indicating risk of aneuploidy while sticky chromosomes indicate a highly toxic, irreversible effect probably leading to cell death (Fiskesjo, 1985). According to Kong and Ma (1999), there is a hypothesis that stickiness of chromosomes may cause incomplete separation of daughter chromosomes as a result of cross-linkage chromo proteins. Sticky chromosomes indicate a highly toxic, irreversible effect and probably leading to cell death.

Thirty heavy metal resistant bacteria were isolated from sewage of industrial effluents, garages and petrol pumps of Barak Valley region of Assam, India, against cadmium and lead. They were identified as *Pseudomonas* sp., *Klebsellia* sp., *Staphylococcus* sp., *Proteus* sp. and *Bacillus* sp. Among all, six isolates exhibited high resistance to heavy metals with MIC for heavy metals ranging from 800 µg/ml to 1800 µg/ml. *Bacillus* sp. was found to be have high resistance pattern against cadmium (1800 µg/ml) and Lead (1200 µg/ml). *Pseudomonas* sp. (Ps/P-4) isolated from petrol pump and *Klebsellia* sp. (K/G-1) from garage also showed high MIC values against cadmium as 1800 µg/ml and 1600 µg/ml (Soumitra Nath et al., 2012). In the present study, the MIC of cadmium for both isolates (A and B) was 0.4 mM. Both isolates A and isolate B can degrade cadmium from 0.01 gm/100 ml to 0.04 gm/100 ml after 96 hours of incubation period. Similarly this study indicates the possible degradation of Cd by the two isolates A and B and also indicates that more ability to degrade cadmium than isolate B. Recently, research in heavy metal removal from wastewaters and sediments has emphasized on the development of materials with increased affinity, capacity and selectivity for target metals (Gadd and White, 1993; Tortura, 1996). The use of microorganisms to sequester, precipitate, or alter the oxidation state of various heavy metals has been extensively studied (Shen and Wang, 1993). Some workers have studied the mechanism of heavy metal biosorption using pure microbial species (Nakajima and Sakaguchi, 1986). As a result, a wide variety of bacteria have been reported to oxidize heavy metals in fresh and marine waters, soils, and sediments (Ehrlich, 1996). So the findings of our present study are similar or partially similar with the above described findings of various researchers.

5. Conclusion

The present study deals with isolation and characterization of cadmium degrading bacteria isolated from BSCIC industrial areas, Rajshahi. The use of microbial populations specifically adapted to high concentrations of cadmium will increase the ability to remediate cadmium contaminated sewage soils and it may stimulate the growth of plants. Efficient cadmium tolerant bacteria may have the cadmium degrading and utilizing ability and can be further used as bioremediation and growth stimulating factor in polluted area.

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BIODEGRADATION OF DIAZINON (AMCOZINON 60EC) BY SOIL BORNE BACTERIA AND ASSESSMENT OF CYTOTOXICITY OF PESTICIDE ON *Artemia salina* (NAUPLII)

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Abstract

Biodegradation of diazinon (Amcozinon, 60EC) was investigated using microorganisms isolated from rice field having 10 years history of using diazinon. Samples of diazinon treated soil were inoculated in mineral salts medium supplemented with 2 µg/ml diazinon and a bacterial strain was isolated capable of degrading diazinon. Morphologically, it was gram negative, rod shaped, motile and the viable cells were as 35×10^7 CFU/ml. Biochemically, it was catalase positive, methyl red negative, TSI positive, non-lactose fermenting, having starch, mannitol salt, urea and citrate utilizing ability. Then it was identified as *Pseudomonas* sp. with 96% identity through 16S rRNA gene sequencing. The optimum culture condition for the isolate was found at temperature 40°C and at pH 8.5. It showed highest growth in peptone among different carbon sources and it also could grow in different salt concentrations. The biodegradation efficiency was studied by observing bacterial growth in different diazinon concentrations ranged from 2 µg/ml to 50 µg/ml for 8 days and highest bacterial growth was found at fourth day in case of 25 µg/ml diazinon concentration. The toxicity of diazinon was evaluated through brine shrimp lethality assay and LC₅₀ value was 9.36 µg/ml only after six hours. The isolated bacterial strain was resistant to penicillin, cefuroxime and cefixime, and MIC values of gentamicin and amoxicillin were 25 µg/ml and 50 µg/ml, respectively. Another important finding was that the bacterial isolate did not show any inhibitory behavior against Rhizobacteria. So, the isolated bacteria can be applied to clean the such hazardous pesticides in the environment through bio-augmentation.

Keywords: Diazinon (Amcozinon 60EC), Biodegradation, 16S rRNA gene sequencing, *Pseudomonas* sp., Cytotoxicity.

1. Introduction

As a developing country, the use of pesticides in Bangladesh has increased many times during the last 20 years. In 1995, the total consumed pesticide was 7400 metric tons in Bangladesh. But in 2015, it increased 6 times and the consumed amount was 53460 metric ton (BBS). According to World Health Organization, Rajshahi is one of the major hotspots for using pesticides in Bangladesh (Craig Meisner, 2004). Diazinon, Cypermethrin, Dichlorvos, Malathion, Carbofuran and Mancozeb are the top listed pesticides in the market nowadays (Ali et al., 2002). Diazinon is commonly used in rice fields to control insects (e.g., leaf hoppers, stem borers, aphids, beetles, etc) (Krishi Diary, 2009). It is a colorless to dark brown liquid, and is denser than water (1.116 g/cm³). The IUPAC name of Diazinon is *O,O*-Diethyl *O*-[4-methyl-6(propan-2-yl)pyrimidin-2-yl] phosphorothioate. It's trade name include Spectracide, Knoxout, Basudin, etc. The U.S. EPA has classified diazinon as a toxicity class II pesticide and LD₅₀ of this pesticide is 350 to 400 mg/kg for humans (CDPR, 2011). In 1999, the Health Effects Division, Office of Prevention, Pesticides and Toxic Substances, EPA, reported that "diazinon is one of the leading causes of acute reactions to insecticide use reported as poisoning incidents in the U.S." Diazinon affects the nervous system through the inhibition of AchE, an enzyme needed for proper nervous system function. It is

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also a mutagen. Long-term exposure of it may damage the developing fetus or may cause birth defects, nerve damage and liver damage. The indiscriminate use of pesticides to control major pests and diseases has put environment in jeopardy and created a heavy disturbance in the ecosystem including plants, animals and human beings (Subashini *et al.*, 2007). Mainly synthetic pesticides has serious drawback including its persistence in the environment, toxicity to human beings, wild life including pollinator and economically beneficial insects (Brown, 1986; Georghiou and Taylor, 1977) and finally higher cost of crop production (Khan and Mannan, 1991). Considering the toxic effects of pesticides, various biological strategies are generally devised to remove such harmful pesticides from the environment through a process known as “bioremediation”. The most common type of bioremediators are the soil-borne bacteria such as *Pseudomonas* sp., *Bacillus* sp., *Serratia* sp., etc. The present study describes the isolation and characterization of such a bacterial strain which can de-contaminate and detoxify diazinon from the contaminated soil.

2. Materials and Methods

2.1. Collection of Soil Sample, Pesticide and Isolation of Bacteria

Samples of diazinon (amcozinon) treated soil were collected from rice cultivating fields (Khorkhori bypass, Rajshahi), which had 10 years of histories of diazinon uses. The soil samples were collected about 15 cm below the soil surface using a sterile spatula in sterile polythene bags from different sites of the rice field and were collected 10 days after the application of pesticides. The collected soil samples were ground and passed through 2 mm sieve. Collected soil samples were used as a source of inoculum for enrichment culture and isolation of bacteria capable of degrading diazinon. Commercial grade diazinon (Amcozinon 60EC) was procured from the local pesticide shop from Katakhal, Rajshahi and used for the experiment.

One gram diazinon treated soil sample was suspended to a 250 ml Erlenmeyer flask containing 100 ml of minimal salts (MS) media supplemented with 2 µg/ml concentration of diazinon. Control flasks without an inoculum were also prepared to take account of any abiotic disappearance of diazinon. The primary enrichment was incubated for three days at 37°C with shaking at 120 rpm on a temperature controlled orbital shaker (RivoTEK, TC344, India). When the cultures reached adequate turbidity, they were plated on minimal salts agar containing diazinon. Well grown bacterial colonies were picked and further purified by streaking. The isolated strain (isolate A) was maintained by weekly passage in liquid mineral salts medium containing diazinon. Bacteria from soil sample grown in the MS media supplemented with diazinon was considered to be capable of degrading diazinon and was used as a source of inocula in subsequent experiments.

2.2. Characterization of Bacterial Isolate

Colonial morphology (e.g., shape, size and color of the bacterial colony), Gram’s staining, motility test, viable cell counting, etc. morphological tests were conducted and bacterial morphology was observed under a light microscope (LABOMED, CXL, USA). Methyl red, catalase, macconkey, starch agar, mannitol salt agar, simmon citrate agar, TSI agar, urea agar, etc. tests were performed to characterize the isolate.

Effects of pH, temperatures, carbon sources and different salt concentrations on bacterial growth were performed to study the stability of the bacterial isolates for the biodegradation of pesticides and these experiments were conducted in an Erlenmeyer flask containing 2 µg/ml of pesticides in 100 ml minimal salt broth. After sterilization by autoclaving the flasks were cooled to room temperature and inoculated with the bacterial cultures and maintained at different temperatures (25°C, 30°C, 35°C and 40°C) for the test of temperature effects; maintained at different pH (6.5, 7, 7.5, 8, 8.5 and 9.5) for checking the pH effects; added 1g of various carbon sources (glucose, sucrose, peptone and glycerol) for examining the effects of carbon sources and maintained salt concentrations (1%, 5%, 10%, 15%, 20% and 25%) for observing the salt tolerance of the bacterial isolate and

incubated at 37°C. The bacterial growth was measured by observing the optical density (OD) at 660 nm using UV– spectrophotometer (ANALYTIK JENA AG, SPOKOL 1500/1, GERMANY) after different time intervals.

Molecular identification and characterization of the isolated bacteria was performed through the following steps: extraction of chromosomal DNA, amplification of 16S rRNA gene, purification of PCR products, cycle sequencing, purification of cycle sequencing products, detection of nucleotides and sequence analysis. The genomic DNA of the isolated diazinon degrading bacterium was extracted (about 1465bp) using phenol/chloroform method (indicated by the 'L1' in the Figure 3). The 16S rRNA genes were amplified by PCR using 16S rDNA specific primer forward primer 27F 5'-AGAGTTTGATCMTGGCTCAG-3' and reverse primer 1492R 5'-GGTTACCTTGTTACGACTT-3'. The PCR reactions were carried out in thermal cycler (Applied Biosystem 9700, USA) using following amplification conditions: an initial denaturation step at 95°C for 5 min, followed by 30 cycles of denaturation at 94 °C for 1 min, annealing at 55 °C for 1 min, extension at 72 °C for 1 min and the final extension at 72°C for 10 min. The PCR products were purified and were sequenced on both strands on genetic analyzer (Prism 310, USA). The sequences were then edited by bioinformatics software Chromas.

2.3. Degradation Efficacy, Cytotoxicity and Resistance Pattern of Isolated Bacteria

Diazinon degradation efficiency of the isolated bacterial strain was observed in MS media supplemented with different doses of diazinon (2 µg/ml to 50 µg/ml) at optimized conditions. Cytotoxic activity of diazinon was evaluated through brine shrimp (*A. salina*) lethality assay (Ramesh *et al.*, 2008). The antimicrobial susceptibility test of the isolate was performed against seven antibiotics following the Kirby-Bauer (1966) disc diffusion susceptibility test protocol. Again, the MIC (minimal inhibitory concentration) values of gentamicin and amoxicillin were determined by broth tube dilution method. Furthermore, the antagonistic effect of the isolated bacteria was tested against some pure culture strains of environmental and pathogenic bacteria.

3. Results

3.1. Isolation of Diazinon Degrading Bacteria

One pure bacterial strain (Isolate A) was isolated from the pesticide contaminated soil samples by enrichment culture method. The isolate showed the ability to grow in the presence of pesticide and stored in the glycerol stock for further studies.

3.2. Characterization of Bacterial Isolate

The colony characteristics (colony shape, color, margin, opacity, consistency, elevation) of the isolated bacterium were noted after the growth on MS agar for 24h at 37°C under the light microscope. The morphological (Gram staining, motility tests, viable cell counting) and biochemical (methyl red, catalase, macconkey, starch agar, mannitol salt agar, simmon citrate agar, TSI agar, urea agar, etc.) characterization was carried out according to standard methods (Collins *et al.*, 1985) (Table 1). The physiological characterization (pH, temperature, carbon sources, salt concentrations) was observed at 660 nm OD to optimize the culture conditions (Figure 1)

3.3. PCR Amplification and Sequencing of 16S rRNA Genes

The homology of the 16S rRNA gene sequences was checked with the 16S rRNA gene sequences of other organisms using the BLASTN (<http://www.ncbi.nih.gov/BLAST>) algorithm. *Pseudomonas* sp. produced significant 96% identity with the 16S rRNA gene sequencing of the isolated bacteria.

3.4. Diazinon Degradation Assay

The OD at 660 nm of the isolated *Pseudomonas* sp. were measured at concentrations of 2 µg/ml, 4 µg/ml, 6 µg/ml, 8 µg/ml, 10 µg/ml, 15 µg/ml, 20 µg/ml, 25 µg/ml, 30 µg/ml, 40 µg/ml and 50 µg/ml up to eight days and the recorded data were shown on 0 day, 2 days, 4days, 6 days and 8 days (Figure 4).

Table 1. Summarized results of morphological and biochemical tests

Sl. No.	Test name	Results
01	Morphological characteristics	Round shape, smooth surface, elevated texture
02	Gram reaction	—
03	Motility	Motile
04	Viable cell count	35×10^7 CFU/ml
05	Methyl Red test	—
06	Simmons Citrate test	+
07	Catalase test	+
08	MacConky Test	—
09	Urea Agar Base Test	+
10	Mannitol Salt Test	+
11	Triple Sugar Iron Test	+
11	Starch Test	+

The '+' signs indicate the growth of the microorganisms while '-' signs indicate no growth.

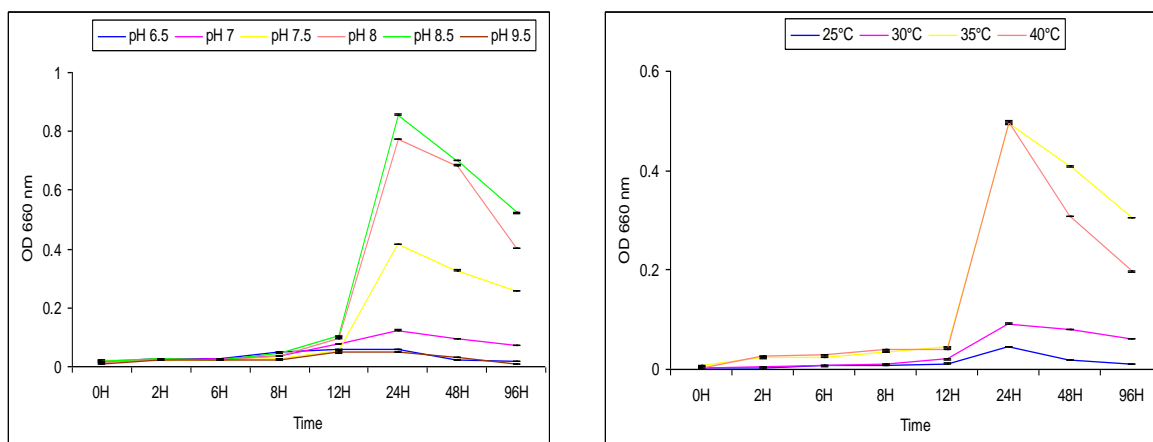


Figure 1. Optimization of pH and temperature for bacterial growth.

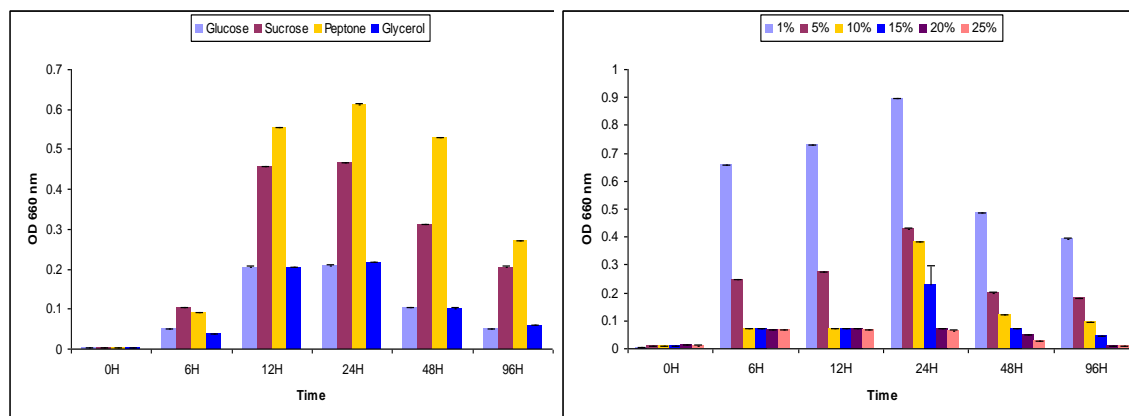


Figure 2. Isolated bacterial growth in different carbon sources and salt concentrations.

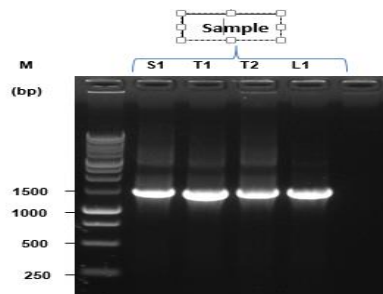


Figure 3. 16S rRNA gene profiling.

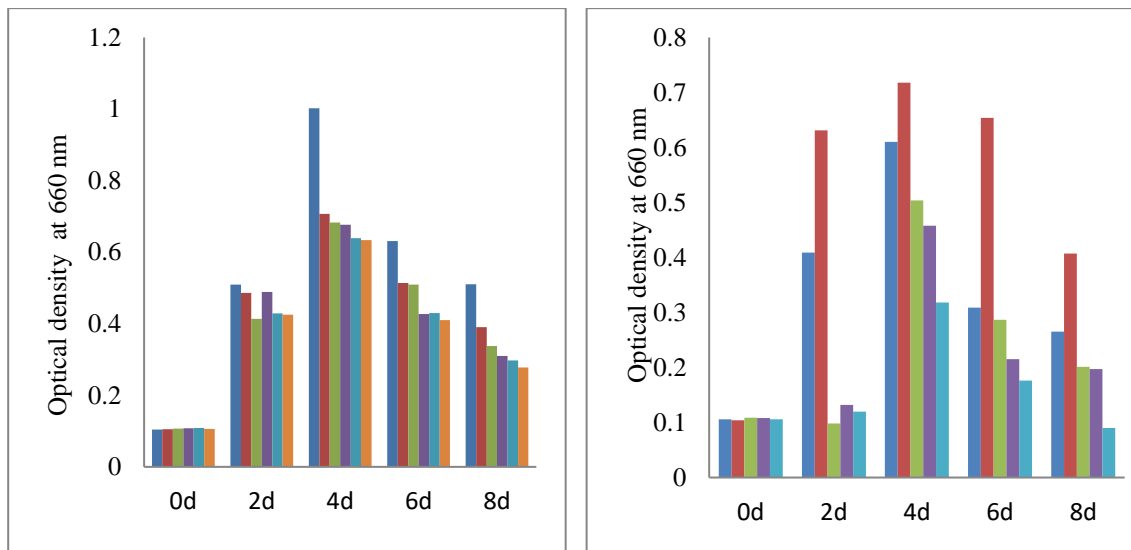


Figure 4. Observation of bacterial growth (OD) in MS media at different concentrations of diazinon.

3.5. Determination of Toxic Effect of Diazinon against *Artemia salina*

In this study, we analyzed the toxicity of the commercial Amcozinon through LC_{50} . The used pesticide showed LC_{50} value 9.36 $\mu\text{g/ml}$ only after 6 hrs of exposure which indicates the high toxicity of amcozinon. Again, after 12 hrs and 18 hrs, the LC_{50} values were 2.30 $\mu\text{g/ml}$ and 1.76 $\mu\text{g/ml}$ and even after 24 hrs there was not any live nauplii.

Table 2. Toxicity of commercially available diazinon (amcozinon) on *Artemia salina*

Test sample	Exposure (hours)	LC_{50} ($\mu\text{g/ml}$)	95% Confidence limits ($\mu\text{g/ml}$)		Regression equation	χ^2 value (1 degree of freedom)
			Lower	Upper		
Diazinon (Amcozinon 60EC)	6	9.362279	2.597826	33.74063	$Y = 3.825697 + 1.216468 X$	3.703869
	12	2.302281	.6171513	8.588656	$Y = 4.576443 + 1.185348 X$.203037
	18	1.760181	2.031175	152.5342	$Y = 4.918788 + .3718225 X$	2.720079
	24	-	-	-	-	-

3.6. Antibiotic Sensitivity Test

The antibiotic sensitivity test of the isolated bacterium was done against seven antibiotics. Among the seven antibiotics, the isolated bacterium was resistant to penicillin, cefuroxime and cefixime; intermediate resistant to tetracycline and amoxicillin; susceptible to ciprofloxacin and gentamicin (Table 3).

Table 3. Antibiotic sensitivity test of the bacterial isolate

Antibiotic name	Disc potency (mcg/disc)	Zone of inhibition (mm)	Response
Penicillin	10	6	Resistant
Amoxicillin	20/ 10	12	Resistant
Ciprofloxacin	5	23	Susceptible
Gentamicin	10	19	Susceptible
Tetracycline	30	16	Intermediate resistant
Cefuroxime	30	6	Resistant
Cefixime	5	6	Resistant

Here, antibiotic sensitivity range: 14 & less than 14mm = resistant, 14-17= intermediate resistant, 18 & more= susceptible.

3.7. MIC of Gentamicin and Amoxicillin

MIC values of gentamicin and amoxicillin against the bacterium were 25 µg/ml and 50 µg/ml, respectively. The results indicate that a less concentration of gentamicin and a moderate concentration of amoxicillin were required to inhibit the growth of this microorganism.

3.8. Antagonistic Effect

The isolated bacterial strain was resistant against *Brevibacillus* sp. and *Acinetobacter* sp. but showed no antagonistic effect against *Rhizobium* sp. Thus it can be used at field level. But the pathogenic bacteria *Brevibacillus* sp. and *Acinetobacter* sp. can be treated by the isolated bacterial strain (Table 4).

Table 4. Antagonistic effect of the isolated bacteria

Bacteria	Inhibition zone (mm)	Response
<i>Brevibacillus</i> sp.(pathogenic)	19	Susceptible
<i>Acinetobacter</i> sp. (pathogenic)	18	Susceptible
<i>Rhizobium</i> RLC (plant bacteria)	6	Resistant
<i>Rhizobium</i> RCA (plant bacteria)	6	Resistant
<i>Rhizobium</i> RVM (plant bacteria)	6	Resistant

4. Discussion

To increase the agricultural yield insecticides plays an important role, but only less than 1% of the pesticides are enough to kill the pests, remaining pesticides enter into the soil and surface water and causes environmental pollution and affect human health also (Battaglin and Fairchild, 2002). Microbial degradation is generally considered to be a safe and effective technique for elimination of toxic substances remaining in the nature. Some microorganisms whether bacteria or fungi, show the capability to degrade pesticides through specific pathways by using them as carbon and energy sources (Aislabie and Lloyd-Jones, 1995). There have been relatively few studies on the microbial degradation of organophosphate pesticides like diazinon. Gunner and Zuckerman first reported (1966) the synergistic action of the bacteria *Arthrobacter* sp. and *Streptomyces* sp. in the degradation of diazinon. Later, a number of studies showed that bacteria of the genus *Pseudomonas*, *Flavobacterium*, *Alcaligenes* and *Rhodococcus* are also involved in the metabolization of diazinon (Kanekar *et al.*, 2004). In the present study, such an indigenous soil-borne bacterial strain, having capability of degrading diazinon was isolated and characterized for the bioremediation of these pesticides contaminated soil. This isolation procedure was completed according to the technique recommended by Manigandan and Nelson (2015). Morphologically, the

bacterial colonies were of round shape, smooth surface, elevated texture. Gram staining of the isolated bacterial strain was performed and it was gram negative (as it showed pink color) and was rod shaped. Motility test indicated that the bacterial isolate was motile. Then the biochemical tests were carried out and the test results were analyzed to identify the isolated bacterial strain. The isolated bacterial strain was methyl red negative, lactose non-fermenting, mannitol salt utilizing and able to detoxify hydrogen peroxide (catalase positive), it could grow on TSI agar and also could utilize citrate. Similar tests were also performed by Holt *et al.* (1998) according to Bergey's Manual of Systematic Bacteriology (taxonomy). It showed highest growth in peptone. It could hydrolyze starch using α -amylase and also urea using urease. Similar experimental results were also obtained by Ningthoujam and Shovarani (2008) and they identified the strain as *Pseudomonas aeruginosa*. In our experiment it was confirmed by 16S rRNA gene sequence which has been emerged as a preferred genetic technique (Clarridge *et al.*, 2004). The optimum growth conditions of isolated bacterium were found at pH 8.5 and 40°C temperature.

After that the diazinon degradation efficiency of the isolated bacterial strain was analyzed and measured on the basis of bacterial growth on diazinon concentrated MS media upto 8 days and this kind of analysis was done by Yadav *et al.* (2015). The reason behind this was the fact that if the OD would rise, it obviously indicated bacterial survivality by the use of toxic diazinon as a carbon source. First of all, when we grew the bacteria on lowest concentration 2 $\mu\text{g/ml}$, we observed highest OD 1.002 on the fourth day. Another concentration 10 $\mu\text{g/ml}$ showed bacterial growth with 0.639 OD, which also proved degradative potentiality of our isolated bacteria on the fourth day. Among all ten various concentrations, the bacteria showed significant growth on 25 $\mu\text{g/ml}$ diazinon concentrated MS media that was also on fourth day. Thus, we found that the bacteria reached it's log phase after four days upto 25 $\mu\text{g/ml}$. However, the ODs of the log phase of the bacteria grown on 30 $\mu\text{g/ml}$, 40 $\mu\text{g/ml}$, 50 $\mu\text{g/ml}$ were 0.504, 0.458, 0.318, respectively on the fourth day which were reduced in comparison to 25 $\mu\text{g/ml}$ at which concentration the bacterial OD was 0.718. Thus, this bacterial strain can be used as a diazinon degrading biological agent through bio-augmentation green technology. Toxicity of diazinon was evaluated using *Artemia salina* and LC_{50} value was obtained 9.36 $\mu\text{g/ml}$ only after six hours and the regression equation was $Y = 3.825697 + 1.216468 X$, while the 95% confidence limits were 2.60 to 33.74 $\mu\text{g/ml}$. Accordingly, after 12 and 18 hours the LC_{50} values were 2.30 $\mu\text{g/ml}$ and 1.76 $\mu\text{g/ml}$. While, after 24 hours, there was not any live nauplii. Similar type of study was performed by Baek *et al.* (2015). Previously it was reported that the LD_{50} value of diazinon in rats was >2150 mg/kg, in dogs was >300 mg/kg and in adult cattle was 10-25 mg/kg (Parasitipedia.net) which were less toxic than we found after 6 hrs in *Artemia salina*. Antibiotic sensitivity test of the bacterial isolate was conducted and at the same time the minimum inhibitory concentrations of gentamicin and amoxicillin against the isolated bacteria was evaluated and we found that the bacteria could inhibit the antibiotic gentamicin upto 25 $\mu\text{g/ml}$ and amoxicillin upto 50 $\mu\text{g/ml}$. Similar result of inhibitory effect was obtained by Lethbridge and Burns (1975). The antagonistic effect of the bacteria was examined to be assured that the isolated bacterial strain had no inhibitory effect against the plant bacteria (e.g., *Rhizobium* sp. etc). So, the biodegrading ability of the bacterial isolate indicates a positive role to reduce pesticides hazardous effects from environment through bioremediation strategies.

5. Conclusion

Our current study recommends a possible application of the isolate in the *in vivo* bioremediation of pesticide (diazinon) contaminated soils and assure pesticides hazards free better environment. The results obtained in this study showed that isolated bacteria was identified as *pseudomonas* sp. through molecular identification which had degradation potential of pesticide (diazinon) at a highest dose of 25 $\mu\text{g/ml}$ diazinon concentration. Our result revealed high toxic effect of diazinon only after 6 hours of exposure. Antibiotic Sensitivity test result showed that isolated bacteria was susceptible to only ciprofloxacin and gentamycin and antagonistic result showed that isolated bacteria wouldn't be harmful for Rhizobacteria at field level.

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APPENDIX

Appendix 1: Probit mortality analysis after 6 hr of exposure on *Artemia salina*

Dose (µg/ml)	log dose	number	kill	% kill	corr %	emp probit	expt probit	wrk probit	weight	final probit
10	.9999897	10	5	50	50	5	5.04	5	6.37	5.03
5	.6989628	10	4	40	40	4.75	4.66	4.74	6.01	4.68
2	.3010268	10	2	20	20	4.16	4.19	4.17	4.71	4.20

Appendix 2: Probit mortality analysis after 12 hr of exposure on *Artemia salina*

Dose (µg/ml)	log dose	number	kill	% kill	corr %	emp probit	expt probit	wrk probit	weight	final probit
10	.9999897	10	8	80	80	5.85	5.76	5.83	5.32	5.73
5	.6989628	10	6	60	60	5.25	5.40	5.24	6.01	5.39
2	.3010268	10	5	50	50	5	4.93	4.99	6.34	4.93

Appendix 3: Probit mortality analysis after 12 hr of exposure on *Artemia salina*

Dose (µg/ml)	log dose	number	kill	% kill	corr %	emp probit	expt probit	wrk probit	weight	final probit
10	.9999897	10	6	60	60	5.25	5.29	5.28	6.27	5.31
5	.6989628	10	6	60	60	5.25	5.18	5.24	6.34	5.19
2	.3010268	10	5	50	50	5	5.03	5	6.37	5.02

APPLICATION OF ARIMA MODEL FOR RAINFALL FORECASTING IN RAJSHAHI

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Abstract

Forecasting of monthly rainfall is not only challenging but also significantly important in drought forecasting in agriculture, irrigation schedule, water resources management and crop pattern design. The goal of this study is to focus on development of a reliable forecasting of rainfall using stochastic methods. In this paper, Box-Jenkins time series seasonal ARIMA (Autoregressive Integrated Moving Average) approach has been used to develop monthly forecasting models for rainfall prediction using monthly rainfall data of Rajshahi, Bangladesh. Seasonal ARIMA model (0, 0, 0) (1, 1, 1) for rainfall was identified as the best model to forecast rainfall for next four years. It is expected that this prediction will help decision makers in efficient scheduling of flood prediction, urban planning, rainwater harvesting and crop management.

Keywords: Rainfall, Stationary, Seasonal ARIMA, Forecasting.

1. Introduction

Rainfall is one of the most important climatic elements and its forecasting helps the stakeholders who depends on it directly or indirectly to prepare them in advance. Bangladesh is an agro-based country and most of the agricultural products largely depend on the climatic variables and rainfall is one of the priorities. Rainfall forecasting is crucial for making important decisions and performing strategic planning. The ability to predict and forecast rainfall quantitatively guides the management of water related problems such as extreme rainfall conditions like droughts and floods among other issues (Ansari, 2013; Kanna *et al.*, 2010; Htike and Khalifa, 2010; Meher and Jha, 2013). Stochastic and time series models have been used for predictions which are usually related to the data. There are many statistical procedures to forecast rainfall data. The most important time series model is the Box-Jenkins approach. This approach known as ARIMA (Autoregressive Integrated Moving Average). If the time series shows seasonal component, ARIMA model should be expended to include this component and then called seasonal ARIMA, SARIM, ARIMA has widely been exercised overs the years to predict the rainfall trend (Mahsin *et al.*, 2012; Shamsnia *et al.*, 2011), prediction of ozone concentration (Beldjillali *et al.*, 2016), forecasting of carbon dioxide emissions (Rahman and Hasan, 2017), evapotranspiration (Valipour, 2012). Cadenas *et al.*, (2016) compared the effect of the various climatic variables such as air temperature, atmospheric pressure, wind direction and solar radiation or relative humidity, as well as delayed wind speed on the performance of the multivariate model of wind speed prediction based on nonlinear autoregressive exogenous artificial neural network (NARX) and ARIMA for some areas in Mexico. Yoosef Doost *et al.* (2017) analyzed and evaluated ARIMA model with GFDL CM2.1 and GM3 Atmosphere-Ocean General Circulation Models (AOGCMs) to assess the effects of climate change on temperature and precipitation in the Taleghan basin.

Rainfall forecast study for Dhaka Division of Bangladesh has been done by Mahsin *et al.*, (2012). Bari *et al.* (2015) used ARIMA model to forecast the rainfall of Sylhet city. Nury *et al.* (2014) in his study forecast the monthly rainfall of Sylhet and Moulovibazar districts using seasonal ARIMA model. The area of Rajshahi is one

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of the vital agricultural based and tourist attracting locations in Bangladesh. Urban Rajshahi and some other regions including Padma river basin are facing rapid ground water depletion. Besides, excessive iron and arsenic contamination has an adverse impact in drinking water supply. To pursue a sustainable alternative source of water supply, uses of rainwater has become a suitable option in many parts of the region. Therefore the aim of this study is to focus on development of a reliable forecasting of rainfall over Rajshahi to manage water resources.

This paper is organized as follows: Section 2 gives the brief description of materials and methods. Forecasting accuracy criteria, which are used to compare the performances of forecasting ability of the models, are defined in section 3. Empirical results of rainfall forecasting of Rajshahi are shown in section 4. Finally, section 5 provides some relevant conclusions.

2. Materials and Methods

2.1. Study Area

The study area, Rajshahi is situated within Barind Tract, 23 m (75 ft.) above sea level and lies at 24°22'26"N 88°36'04"E. The city is located on the alluvial plans of the Padma River which runs through southern side of the city. The climate of Rajshahi district is tropical wet and dry. The climate of Rajshahi is generally marked with monsoons, high temperature, considerable humidity and moderate rainfall. The highest rainfall is observed during the months of monsoon. The annual rainfall of the district is about 1448 mm (57.0 inches) but the variation from year to year is appreciable.

2.2. Data Collection

Bangladesh Meteorological Department (BMD) collects rainfall data for Bangladesh through its 34 stations. Rajshahi is one of them. In this study we used the total monthly rainfall data covering the period from January 1980 to December 2016, containing 444 observations.

2.3. Software Used

The various kinds of software that used during the process include Microsoft Excel (MS-Excel) and Eviews 8.

2.4. Methodology

In time series analysis, the Box-Jenkins methodology applies Autoregressive Moving Average (ARMA), Autoregressive Integrated Moving Average (ARIMA) or Seasonal Autoregressive Moving Average (SARIMA) models to establish the best fit of time series to make forecasts. The order of ARIMA model p,d,q present the order of the auto regressive (AR) part; degree of differencing involved and order of the moving average (MA) part respectively. The general form of the ARIMA (p,d,q) can be written as

$$\nabla^d y_t = C + \phi_1 \nabla^d y_{t-1} + \phi_2 \nabla^d y_{t-2} + \dots + \phi_p \nabla^d y_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (2.1)$$

Or in backshift notation,

$$(1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p) \nabla^d y_t = C + (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q) \varepsilon_t \quad (2.2)$$

Where C= constant term, ϕ_i =ith autoregressive parameter, θ_j = jth moving average parameter, ε_t is the error term and B^k is the k^{th} order backward shift operator.

Seasonal ARIMA(P,Q,D) parameters may also identify for specific time series data. These parameters are seasonal auto-regressive (P), seasonal differencing (D) seasonal moving average (Q). The general form of the seasonal ARIMA (p,d,q) (P,D,Q)_s model can be written as

$$\phi_{AR}(B) \phi_{SAR}(B^s) (1 - B)^d (1 - B^s)^D y_t = \theta_{MA}(B) \theta_{SMA}(B^s) \varepsilon^t \quad (2.3)$$

= Where s= number of periods per season, ϕ_{AR} = non-seasonal autoregressive parameter, θ_{MA} = non-seasonal moving average parameter, ϕ_{SAR} = seasonal autoregressive parameter, θ_{SMA} = seasonal moving average parameter.

The Box-Jenkins methodology consists of four steps: (i) Model identification, (ii) Estimation of the model parameters (iii) Diagnostic checking of the model adequacy and (iv) Forecasting. The first step involves testing whether the time series is stationary and if there is significant seasonality that needs to be modeled.

The auto correlation function (ACF) and the partial auto correlation (PACF) are the most important tools for choosing the orders of the ARIMA model. The ACF quantifies the extent of linear dependence between time series observations separated by a lag k which provide information regarding stationarity of the series. The ACF and PACF help to determine how many moving average and auto regressive terms are necessary to reveal one or more of the following characteristics: time lags where high correlations appears seasonality of the series and the trend either in the means or variances of the series.

Stationary of data can also be identified by using a number of unit root tests. Moreover, we have applied some formal unit root tests for checking the stationary of the series. Unfortunately, it is well known that unit-root tests have low power and that results can vary with the types of test used and the number of lags included in the test equations. For this reason, it becomes a strategy among there searchers to examine the results of several test procedures in order to draw conclusions on stationary. With this in mind, three unit root tests are performed: (i) most widely used Augmented Dicky-Fuller (ADF) test of Dicky and Fuller (1979, 1981) (ii) the asymptotically most powerful DF-GLS test of Elliott *et al.*, 1996 and (iii) the Kwiatkowski *et al.*, 1992, LM test (KPSS). The null hypothesis of ADF and DF-GLS tests is that a time series variable has a unit root while KPSS test is that a variable is stationary. A common strategy is to present results of both ADF/DF-GLS and KPSS tests, and show that the results are consistent (e.g., that the former reject the null while the later fail to do so and vice-versa). The lag length is selected by using the Akaike Information Criteria (AIC), setting the maximum lag at 12.

The second step is the model parameter estimation in which least square or maximum likelihood techniques can be used. The third step is the diagnostic checking where the residuals from the fitted model are examined, usually by correlation analysis through the residual ACF and PACF. If the residuals are correlated and the parameters of the model are insignificant then the model should be needed to go back to the identification stage. Otherwise, if the model parameters are significant and the correlations are white noise then the model is competent to present the time series (Suhartono, 2011). The best model would be used for forecasting purposes. The best model has to be chosen by comparing the forecasting abilities of the competent models. For comparing the forecasting ability of the competing models, the data set is divided into two sub-data sets: (i) a training set to estimate the model parameters and (ii) a test set to evaluate these models by calculating error functions. There are 444 observations in the rainfall series. The first 420 observations from 1980:1 to 2014:12 are used to build the model, the last 24 observations from 2015:1 to 2016:12 to check the forecast ability of the models. To assess and compare the forecasting performance of the models, three types of forecasting accuracy criteria of the test sets data have been adopted, which are shown in the next section.

3. Forecast Performance Measures

To evaluate forecast accuracy as well as to compare among different models fitted to a time series, we have used the three performance measures. They are Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE), which are defined by

$$MAE = \frac{1}{n} \sum_{t=T+1}^{T+n} |y_{real,t} - y_{forecast,t}| \quad (3.1)$$

$$RMSE = \sqrt{\frac{\sum_{t=T+1}^{T+n} (y_{real,t} - y_{forecast,t})^2}{\sum_{t=1}^T (y_{real,t} - \bar{y})^2}} \quad (3.2)$$

$$MAPE = \frac{1}{n} \sum_{t=T+1}^{T+n} \left| \frac{y_{real,t} - y_{forecast,t}}{y_{real,t}} \right| \times 100 \quad (3.3)$$

Where $y_{real,t}$ and $y_{forecast,t}$ are the real and forecast data point at time t respectively, \bar{y} is the mean of real data, T is the number of observation in the trial series, and n is the number of data points forecasted in the test series. Smaller values of the criteria indicate the better forecast of the model.

4. Results and Discussion

We have used the famous Box-Jenkins (1976) modeling philosophy for choosing an appropriate ARIMA model for the monthly rainfall series over the period 1980:1-2016:12. Then the appropriate model has been used to forecast the rainfall series over the period 2017:1-2020:12. Good references on ARIMA models and standard forecasting techniques are in Box and Jenkins (1976), Pankratz (1991) and Granger and Newbold (1986).

The first step is to check whether the data are stationary and if there is seasonality exists then the series can be modeled. The time series plot of the monthly rainfall is presented in Figure 1. The descriptive statistics for our data are shown in Table 1. Figure 1, shows that there is a seasonal cycle of the series and moving through a constant values. The data seems to be stationary; however, there is clear seasonality with periodicity of one year (12 month) in the data set.

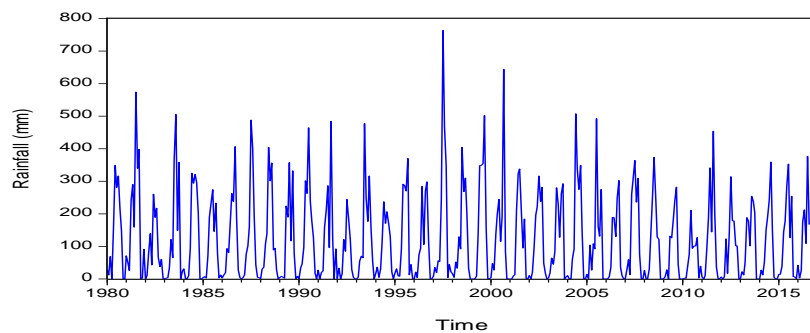


Figure 1. Time series plot of Rajshahi rainfall (mm) for the period 1980-2016.

Table 1. Basic statistics for Rajshahi monthly rainfall data in millimeter

No of observations	Mean	Std. dev.	Min.	Max.
444	120.011	134.265	0.000	763.000

Plots of ACF and PACF of rainfall time series are shown in Figure 2. If the series are auto-correlated over long lag length, it indicates that the series contains some permanent effect and the series may not be stationary. The ACF function shown in Figure 2 shows clear seasonality variation in the present data set. Therefore, the original data series need to be seasonal differencing to remove the seasonal variation. After seasonal differencing ACF and PACF are shown in Figure 3. This figure shows that the series is stationary without seasonality, since ACs at all the lags are within the 5% confidence limits.

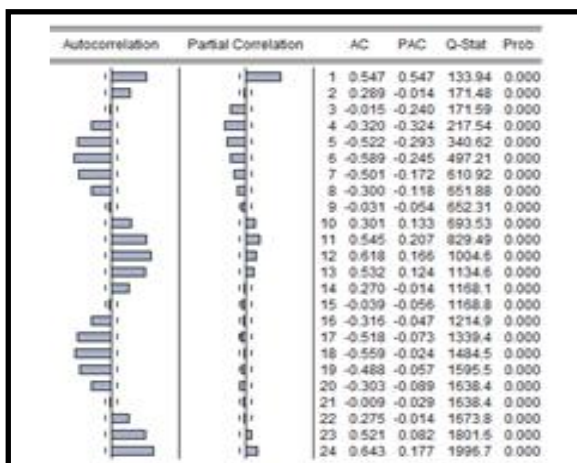


Figure 2. Auto correlation function (ACF) and partial auto correlation function (PACF) of Rajshahi rainfall series.

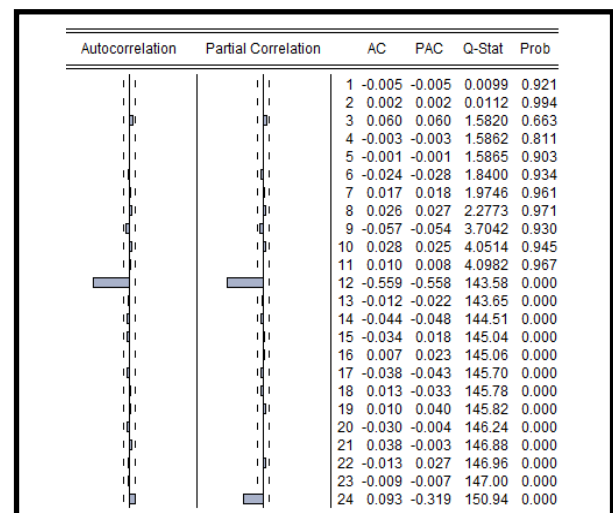


Figure 3. First order regular difference and seasonal difference of rainfall data for ACF and PACF plot.

The de-seasonalized series is shown in Figure 4.

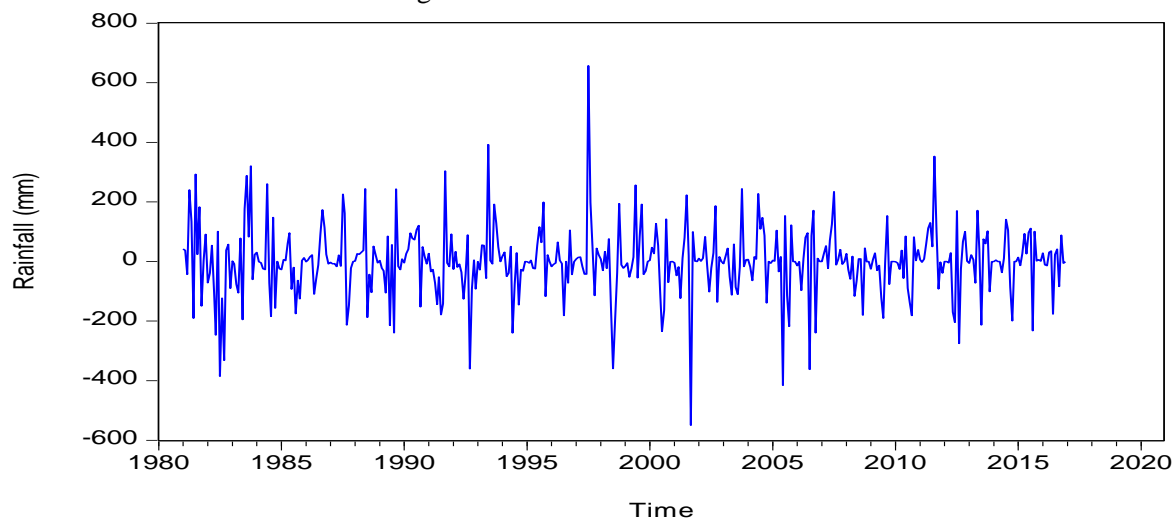


Figure 4. De-seasonalised series of Rajshahi rainfall for the period 1980-2016.

Moreover, we have applied some formal unit root tests for checking the stationarity of the de-seasonalised series. The results of ADF, DF-GLS and KPSS tests have been reported in Table 2. For both ADF and DF-GLS tests show the same results when only intercept term and both intercept and trend terms are included in the test model. The null hypothesis of existing unit root in the series is rejected at 5% level of significance. That is, the rainfall series is stationary. While KPSS test cannot reject the null hypothesis that the series is stationary at 5% level of significance. Thus, the three unit root tests suggest that the rainfall series is stationary.

Table 2. Unite root tests for seasonal differences series

	Lag	Constant	Constant & Trend
ADF	11	-11.1026*	-11.1164*
DF - GLS	12	-5.6245**	-9.1318**
KPSS	3	0.0135**	0.0134*

* And ** indicate statistical significance at the level 1% and 5% levels of significance respectively.

We expect seasonal ARIMA process of the form seasonal ARIMA (p, 0,q)(P,0,Q)12. We have used the famous Box-Jenkins,1976 modeling philosophy for choosing competent ARIMA models for the monthly rainfall series over the period 1980:1-2016:12. As per the modeling philosophy 10 seasonal ARIMA models are identified which are competent to fit the monthly rainfall series. The competent models are shown in Table-3. For comparing the forecasting ability of the competing models, the data set is divided into two sub-data sets: (i) a training set to estimate the model parameters and (ii) a test set to evaluate these models by calculating error functions. The competent models are estimated using the trial data over the period 1980:1-2014:12 to forecast the test data over the period 2015:1-2016:12. Then the values of forecasting accuracy criteria - mean absolute error (MAE), root mean square error (RMSE) and mean absolute percentage error (MAPE) are estimated which are shown in Table-3. Then we have chosen the appropriate ARIMA model from the competent models lowest forecasting error according to the three forecasting accuracy criteria mention in Section 3. Table 3 shows the ARIMA (0, 0, 0) (1, 1, 1) has the lowest forecasting error according to the 3 criteria. Thus, we have chosen the ARIMA (0, 0, 0) (1, 1, 1) model as an appropriate model for the monthly rainfall data used in this study. Finally, this model is used to forecast the future 4 years rainfall over the period 2017:1-2020:12. The estimates of the model are shown in Table 4.

Table 3. Competent models and performance evaluation.

Models	RMSE	MAE	MAPE
Seasonal ARIMA(1,0,1)(1,1,1)	62.463	44.662	314.083
Seasonal ARIMA(0,0,0)(1,1,1)**	62.270	44.254	310.338
Seasonal ARIMA(1,0,1)(0,1,1)	64.071	47.104	298.907
Seasonal ARIMA(1,0,1)(1,1,0)	81.964	54.665	324.294
Seasonal ARIMA(1,0,0)(0,1,1)	64.042	47.053	298.451
Seasonal ARIMA(0,0,1)(0,1,1)	64.082	47.172	299.678
Seasonal ARIMA(2,0,0)(0,1,1)	64.018	46.973	297.757
Seasonal ARIMA(0,0,1)(1,1,1)	62.299	44.258	310.227
Seasonal ARIMA(0,0,0)(0,1,1)	64.081	47.172	299.651
Seasonal ARIMA(1,0,0)(1,1,1)	62.287	44.321	311.082

(** is the selected as the best model for the data)

Therefore we accept the seasonal ARIMA (0, 0, 0) (1, 1, 1) as the most appropriate model for forecasting rainfall in Rajshahi. The estimates of parameters of the fitted seasonal ARIMA (0, 0, 0) (1, 1, 1) model are shown in table 4.

Table 4. Estimates of ARIMA (0, 0, 0) (1, 1, 1) model

Variable	Coefficient	Std. Error	t – Statistic	Prob.
C	-0.494439	0.379274	- 1.303645	0.1931
SAR(12)	-0.116956	0.048804	-2.396475	0.0170
SMA(12)	-0.948723	0.013079	-72.53965	0.0000

The best and the most adequate seasonal ARIMA (0, 0, 0) (1, 1, 1) model can be used for forecasting purposes. This model was used for forecasting the monthly rainfall values for period January 2017 to December 2020, Figure 6. The forecast values show similar pattern of original data series.

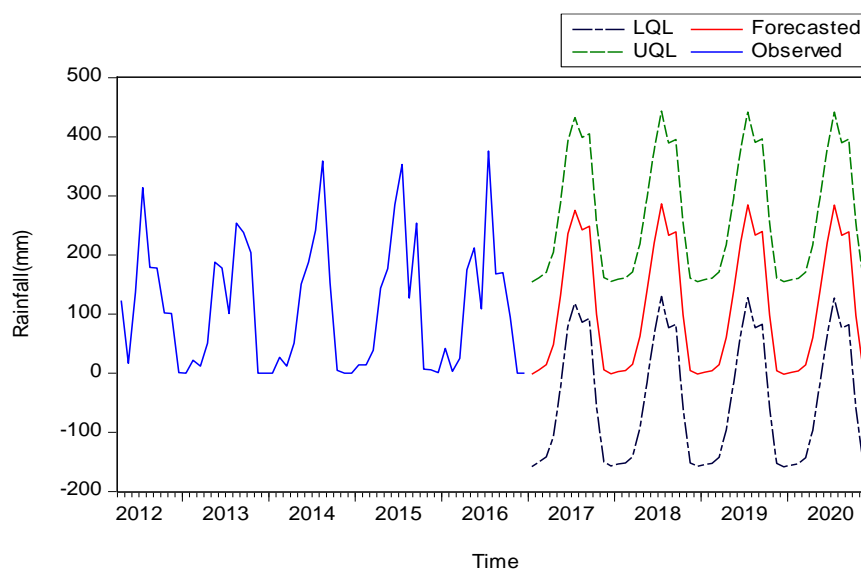


Figure 6. Observed and forecasted data with 95% confidence limit.

5. Conclusions

Time-series analysis is an important tool in modeling and forecasting rainfall. The Box-Jenkins seasonal ARIMA models are applied to forecast monthly rainfall of Rajshahi. Rainfall pattern of Rajshahi shows significant changes over time. Seasonality has significant effects on general pattern of the rainfall series. After having examined we conclude that seasonal ARIMA (0,0,0) (1,1,1) model is the best fit and reliable for forecasting the total recorded monthly rainfall data of Rajshahi in which constant trend can also be noticed.

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HISTOLOGICAL CHANGES IN SOME TISSUES OF FRESHWATER CRAB (*Paratelphusa lamellifrons*) EXPOSED TO PESTICIDES

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Abstract

The present study was conducted to evaluate the effect of two pesticides Morter 48 EC (Chlorpyrifos) and Virtako (mixture of Chlorantraniliprole and Thiamethoxam) on freshwater crab *Paratelphusa lamellifrons* (Alcock, 1900) in the aquarium exposed under controlled conditions. These types of pesticides are applied widely in agricultural field. For histological studies, *P. lamellifrons* were exposed to sub lethal concentrations (0.2ppm, 0.4ppm, 0.8ppm) of Morter 48 EC and (3.75ppm, 7.5ppm, 15ppm) of Virtako respectively for 7 days. In the present study dose dependent mortality and several histological alterations (like vacuolation and fragmentation etc.) were observed in the tissue of ovaries, testes, gills and stomach of freshwater crab *P. lamellifrons*. Hyperplasia, swelling, rogue were noticed in the ovary, testes, gill and stomach of Morter 48EC and Virtako treated crabs. Mortality rates ranged between (50-90)% with LD₅₀ value 0.25 ppm for Morter 48EC, whereas (10-50)% for Virtako with LD₅₀ value 16.00 ppm. Higher mortality rates as well as histological changes were observed for Morter 48EC compared to Virtako pesticide. The histological changes thus observed for both the pesticides in ovary, gills, testes and stomach of *P. lammellifrons* might be used as pesticides (Morter 48EC and Virtako) exposure indicators.

Keywords: Freshwater crab, Pesticide, Histology, Tissue, Histological changes.

1. Introduction

At present many pesticides are extensively used in agricultural operations. These pesticides have various physiological effects on the pests, such as inhibitory effects on growth, food intake, metabolism, enzyme activity and general development (Tungare and Sawant, 2000) and also adverse effects on aquatic animals. The study of the impact of pesticides on aquatic animals is an important aspect of chemical contamination of the aquatic environment (Narra, 2014). Morter 48 EC (Chlorpyrifos) is an Organophosphate group of pesticide which is used in controlling cutworms, corn rootworms, flea beetles, flies, termites, fire ants and lice (Mathur and Tannan, 1999). Some reports reveal the toxicity of Organophosphate group pesticides to crabs (Radhakrishnaiah and Renukadevi, 1990; Senthil *et al.*, 2007; Ghedira *et al.*, 2009).

Virtako is the trade name of a mixture of 20% Chlorantraniliprole (anthranilamides) and 20% Thiamethoxam (Neonicotinoids). Neonicotinoids are relatively new class of synthetic insecticides which resembles the natural product nicotine. Over the last 2 decades, the neonicotinoids, has become the most important and fastest growing of the five major chemical classes of insecticides on the global market (Jeschke and Nauen 2008; Jeschke *et al.*, 2011; Tomizawa and Casida 2011; Casida and Durkin 2013), because of its relatively low mammalian toxicity and generally good environmental characteristics (Pedigo *et al.*, 2009). Chlorantraniliprole (ISO name) is a selective insecticide, developed by the U.S. Company DuPont and then Syngenta.

Kavallieratos (2013) observed chlorantraniliprole is effective against major stored-product insect species. An advantage of this compound is its low mammalian toxicity (Lahm *et al.*, 2007) and its selectivity to beneficial arthropods (i.e. parasitoids, predators and pollinators) (Gradish, 2009; Preetha, 2009; Campos, 2011).

Pesticides at high concentrations are known to reduce the survival, growth and reproduction rate and can produce many visible and non-visible effects in crab (Narra *et al.*, 2012). Due to residual effects of pesticides, important organs like gill, stomach, nervous system, digestive gland and genital organs are damaged (Chourpagar *et al.*, 2014). Histological studies have a way for understanding the pathological condition of the animal by helping in diagnosing the abnormalities or damages of the tissues exposed to toxic stress of heavy metals (Andhale *et al.*, 2011; Maryam *et al.*, 2013). Histological changes not only give an early indication of pollution hazard, but also provide useful data on nature and degree of damage to cells and tissues (Shaikh *et al.*, 2010). It is a common tool for determining the deleterious effects of toxic substance in animals.

Paratelphusa lamellifrons is a very common freshwater crab in our country which found almost all aquatic ecosystem including paddy field (Roy, 2011). Very limited or no work has been done on the histological effects of Morte 48 EC and Virtako on freshwater crab (*Paratelphusa lamellifrons*). Hence, the present study was undertaken to study the effects of Morte 48 EC and Virtako on histological change in some tissues of the organ of *P. lamellifrons*.

2. Materials and Methods

2.1. Experimental Animals

Adult fresh water crab *Paratelphusa lamellifrons* (carapace length ranging from 25 to 30 mm, breadth ranging from 30 to 45 mm and body weight ranging from 15-20g) were captured from the swallow lands of Rajshahi University campus of the Rajshahi City, Bangladesh, during the period from September to December 2013, by using cast net, and were immediately transported to the laboratory in porous plastic container. The crabs were acclimatized in the laboratory condition for two days. The crabs were fed with flour paste once each day. Then the crabs were immediately (after two days) transferred into the experimental aquarium.

2.2. Selection of Pesticides

Two commonly used pesticides such as Morte 48 EC (Chlorpyrifos) and Virtako (mixture of Chlorantraniliprole and Thiomethoxam) were chosen for this experimental work.

2.3. Median Lethal Concentration (LC₅₀)

The acute toxicity tests were conducted in duplicates using 10L experimental aquarium. The duration of the test was 7 days and during the study the experimental crabs were fed. A minimum of 3L water was added for 10 crabs, so that the crabs were fully immersed. The water was renewed each day to avoid depletion of dissolved oxygen in the medium.

The mortality of *P. lamellifrons* was recorded every 24h exposure to pesticides. The LC₅₀ values were obtained by probit analysis (APHA, 1992). Median lethal concentration (LC₅₀) for 24h exposure period of Chlorpyrifos 0.2 ppm, 0.4 ppm and 0.8 ppm and Virtako 3.75 ppm, 7.50 ppm and 15.00 ppm were estimated (Table 1).

2.4. Experimental Design

The effect of pesticides on *P. lamellifrons* was conducted by exposing the crabs (7 groups containing 5 crabs in each group) to sublethal concentrations Chlorpyrifos 0.2 ppm, 0.4 ppm and 0.8 ppm and Virtako 3.75 ppm, 7.50 ppm and 15.00 ppm respectively for 7 days. One group (containing 5 crabs)

was treated with tap water as control group. After treatment period the Control and treated crabs were sacrificed. Ovary, gill, testes and stomach were collected and put in aqueous Bouins fluid. After fixation for 24-30 h, tissues were dehydrated through a graded series of ethanol, cleared in xylene, and infiltrated in the paraffin. Sections of 4-6 μm were prepared from paraffin blocks by using a rotary microtome. These sections were then stained with Hematoxylin-Eosin. Histopathological lesions were examined and photographed using microscope (Olympus, Japan, CH4O) with photographic attachment camera.

2.5. Statistical Analysis

The data was statistically analyzed using SPSS software. Regression and Analysis of variance (ANOVA) were used to determine the significance difference among the pesticides.

3. Results and Discussion

3.1. Mortality Effect of *P. lamellifrons*

The survival rate over a period of 7 days exposure given various doses of chlorpyrifos showed that the percentage of mortality of *P. lamellifrons* depend on the dose of pesticide. The higher dose gave the higher number of death resulted. Mortality rates ranges between (50-90)% with LD₅₀ value 0.25 ppm for Morter 48EC whereas (10-50)% for Virtako with LD₅₀ value 16.00 ppm (**Table 1**). Higher mortality rates were observed for Morter 48EC compared to Virtako (Table 1).

Table 1. Correlation between dose and mortality of *P. lamellifrons*.

Pesticides	Dose (ppm)	% Killed	LD ₅₀ (ppm)	95% confidence limit		χ^2 Value at 1 df
				Upper	Lower	
Morter 48 EC	0.2	50	0.2513687	0.144	0.437	0.1920424
	0.4	80				
	0.8	90				
Virtako	3.75	10	16.00445	7.081	36.169	0.1374178
	7.5	20				
	15.00	50				

3.2. Effect on Behavior of *P. lamellifrons*

Some other effects of the pesticides on *P. lamellifrons* were noticed during the experiment. The crabs exposed to Morter 48 EC did not show any breeding behavior after exposing to the chemical. In the higher two doses crabs stop feeding after 4th day. Their movement was limited. They stayed attached to the glass wall of the aquarium and not swimming. In Virtako mortality rate of *P. lamellifrons* was not very high but some behavioral changes do occur. Exposed crabs did not show any breeding behavior. These chemicals also cause some irritation to the crabs. The exposed crabs constantly tried to leave the aquarium which they normally rarely do.

3.3. Histological Effects

3.3.1. Histological Observation on Ovary

The Histological observation on ovary showed that there was hyperplasia on ovary of crab exposed to different concentration of Morter 48 EC. In the control experiment, ovary was normal, systematically arranged and bright in color. Crab exposed to concentration of lower dose (0.2 ppm) showed mild hyperplasia (Figure 1b:B1) but at higher dose (0.04 ppm and 0.08 ppm) showed severe hyperplasia (Figure 1b:B2 and B3). In case of Virtako there was negligible difference between control and treatment of different doses. Mild hyperplasia

found in higher dose (15.00 ppm) (Figure 2b:F3) whereas mild swelling occurred in low doses (Figure 2b:F1 and F2).

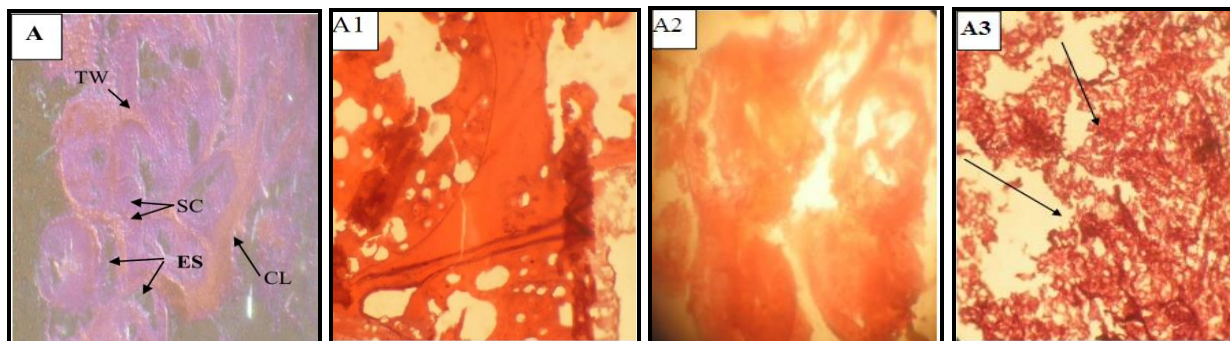


Figure 1a. (A) Histological slides of control tissue of Testes (TW- Thick wall, SC- somatic cell, ES- Empty space, CL- Cell lining); (A1) Testes exposed to Morter 0.2 ppm (mild vacillation), (A2) 0.4 ppm (shows vacillation of cell) and (A3) 0.8 ppm (arrows shows the fragmentation of cell).

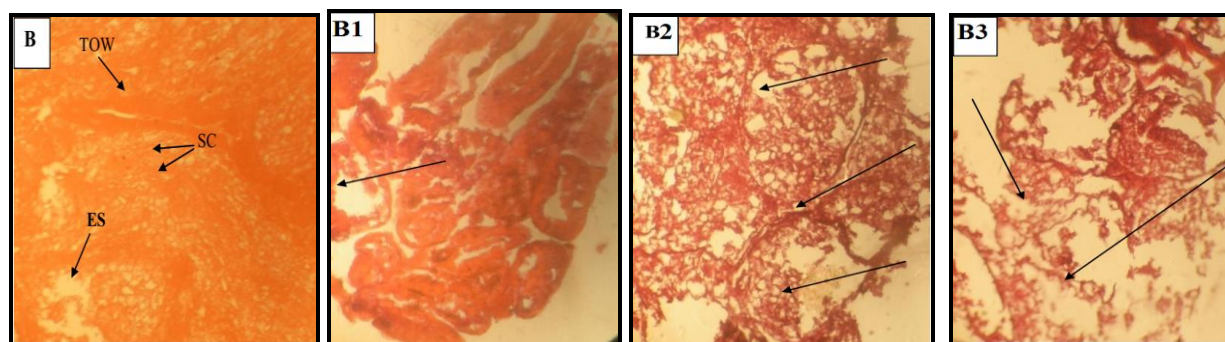


Figure 1b. (A) Histological slides of control tissue of Ovary ((TOW- Thick ovarian wall, SC- somatic cell, ES- Empty space)); (B1) Ovary exposed to Morter 0.2 ppm (arrow shows the vacillation of cell); (B2) 0.4 ppm (arrows shows the fragmentation of cell) and (B3) 0.8 ppm (arrows shows the much fragmentation of cell).

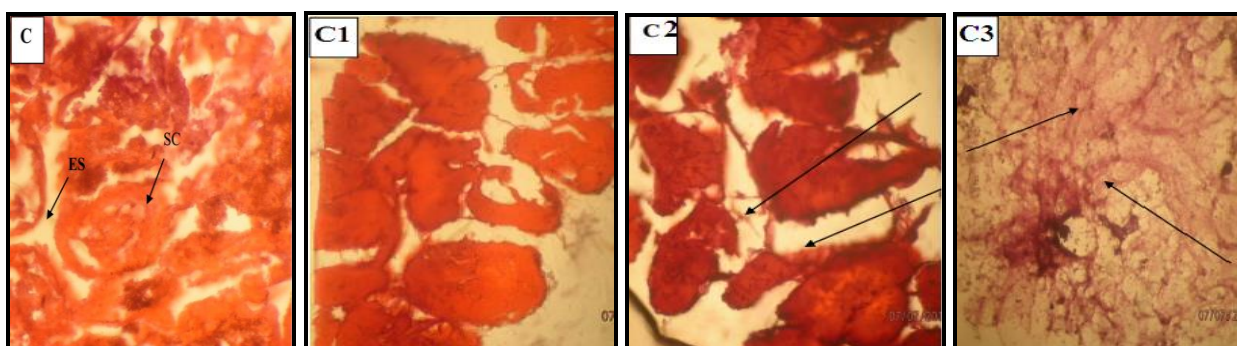


Figure 1c. (C) Histological slides of control tissue of stomach (SC- somatic cell, ES- Empty space); (C1) Stomach exposed to Morter 0.2 ppm (vacillation of cell), (C2) 0.4 ppm (arrows shows the reduced rugae and vacillation of cell); (C3) 0.8 ppm (arrows shows the much reduced rugae and cell fragmentation).

3.3.2. Histological Observation on Testes

The Histological observation on testes showed that there was hyperplasia and swelling on testes of crab exposed to different concentration of Morter 48 EC. In the control experiment, ovary was normal, cells were prominent and bright in color. Crab exposed to concentration of lower dose (0.2 ppm and 0.04 ppm) showed mild swelling, (Figure 1a: A1 and A2) but at higher dose (0.08 ppm) showed hyperplasia (Figure 1a: A3). In case of Virtako there was very low difference between control and treatment of different dose. Mild hyperplasia found in all the doses (Figure 1b: E1 to E3).

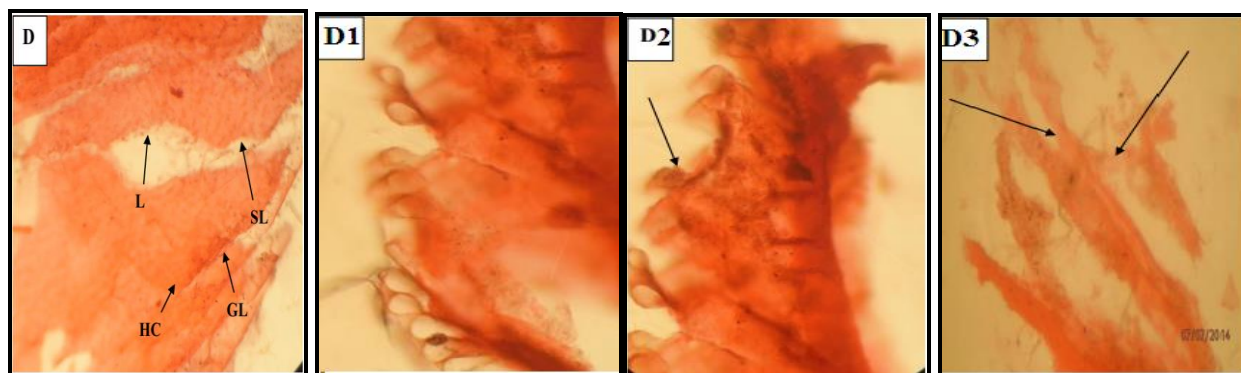


Figure 1d. (D) Histological slides of control tissue of Gill (HC-Haemocoelic, SL- Secondary lamella, GL- Gill lamella, L- lining) (D1) 0.2 ppm; (D2) 0.4 ppm (arrow shows the hyperplasia) (D3) Gill exposed to Morter 0.8 ppm (vacuolation of cell).

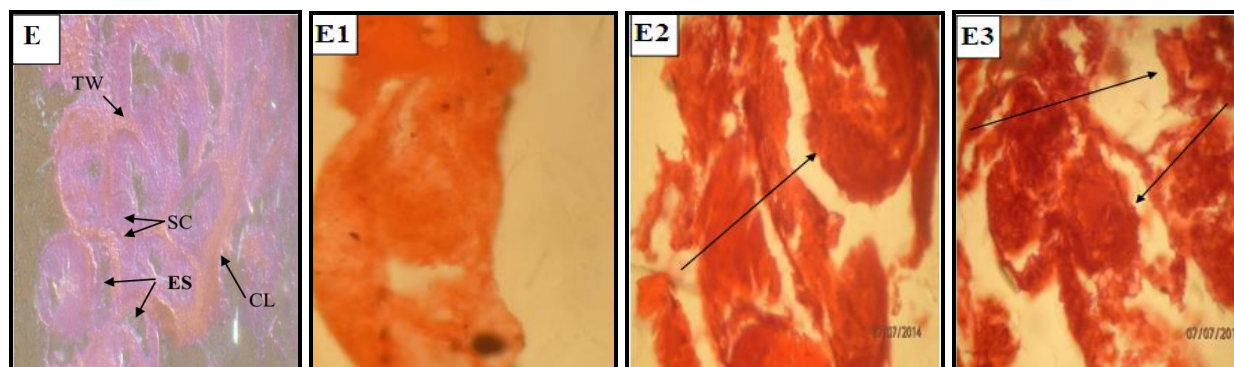


Figure 1a. (E) Histological slides of control tissue of Testes (TW- Thick wall, SC-somatic cell, ES- Empty space, CL- Cell lining); (E1) Testes exposed to Virtako 3.75 ppm (no change found); (E2) 7.5 ppm (arrow shows vacuolation of cell); (E3) 15 ppm (arrows shows much vacuolation of cell).

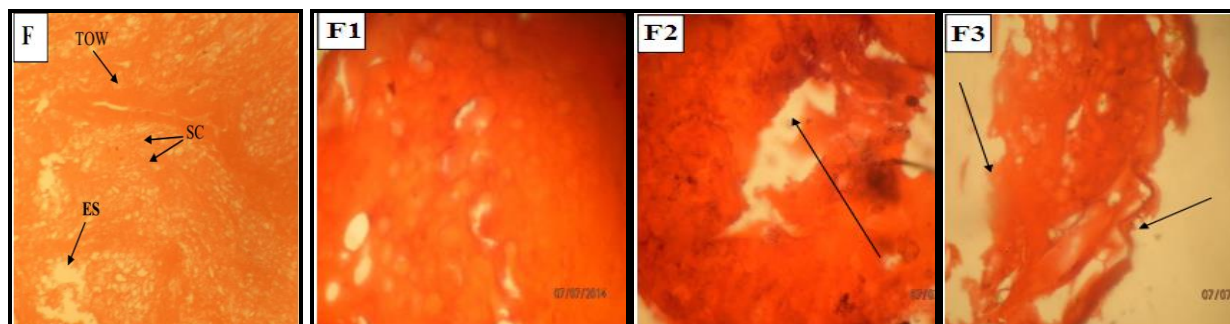


Figure 2b. (F) Histological slides of control tissue of Ovary ((TOW- Thick ovarian wall, SC- somatic cell, ES- Empty space)); (F1). Ovary exposed to Virtako 3.75 ppm (no change found); (F2) 7.5 ppm (arrow shows mild fragmentation of cell); (F3) 15.00 ppm (arrows shows fragmentation of cell).

3.3.3. Histological Observation on Gills

The gill of control crabs was normal in shape and colour. In case of Morter 48 EC at 0.2 ppm, there was no swelling but at 0.4 ppm, there was swollen tip of the gill filaments (Figure 1d: D2). At the higher dose of chlorpyrifos (0.8 ppm) hyperplasia was seen (Figure 1d: D3). On the other hand there was no significant difference between control and treatment exposed on different dose of Virtako (Figure 2d: H1 to H3).

3.3.4. Histological Observation on Stomach

The stomach in the control was found to be without necrosis (Plate 1c:C). The stomach of *P. lamellifrons* was reddish brown colored organ with different mass of muscle and rogue present. The other cells were normal and

systematically arranged. The rogue and other cells were highly reduced in the high dose (0.8 ppm) of Morte 48 EC (Figure 1c: C3). At 0.4 ppm the rogue and other cells also reduced but not higher than 0.8 ppm. In lower dose (0.2 ppm) the same effect present in very low rate (Figure 1c: C1). In case of Virtako there was very low difference between control (2c:G) and treatment of different dose. Mild hyperplasia found in all the doses (Figure 2c: G1 to G3).

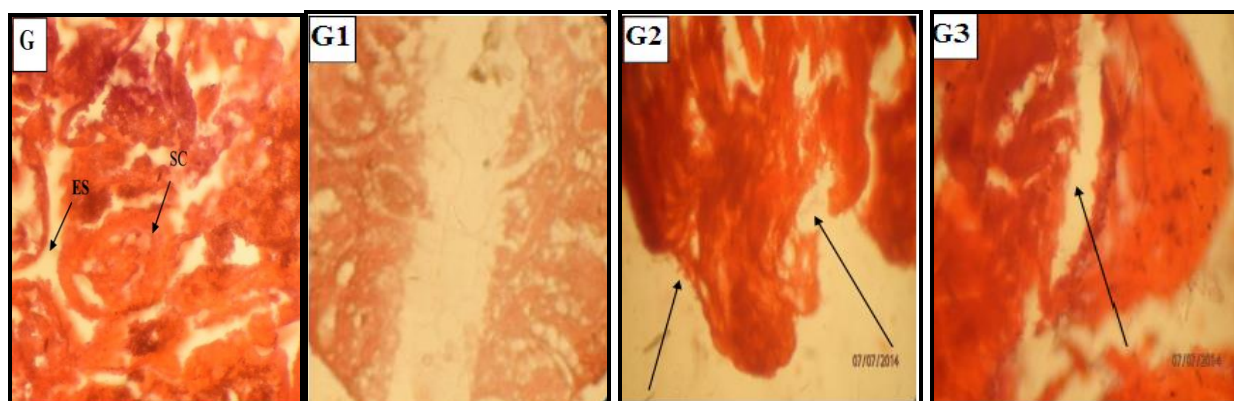


Figure 2c. (G) Histological slides of control tissue of stomach (SC- somatic cell, ES- Empty space);(G1) Stomach exposed to Virtako 3.75ppm (mild fragmentation occur); (G2)7.5 ppm (arrows shows the vacuolation of cell and reduced rugae); (G3)15.00 ppm (arrow shows the fragmentation of cell).

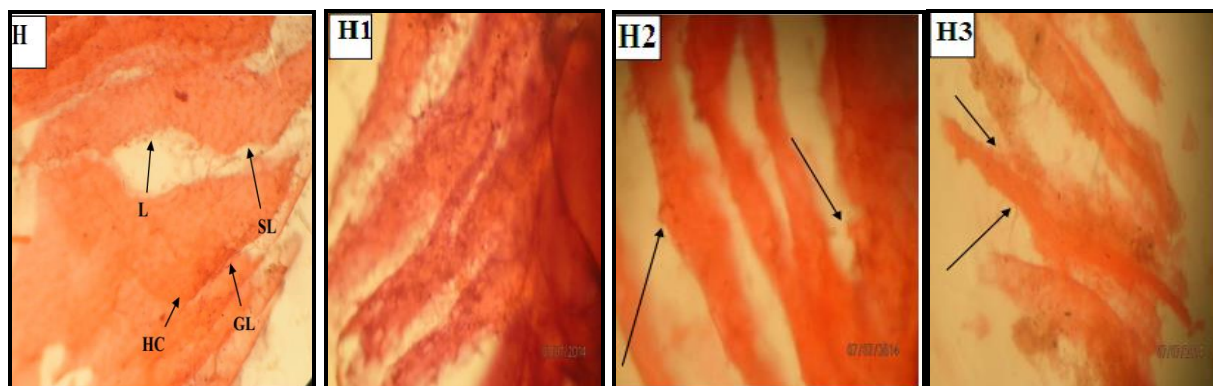


Figure 2d. (H) Histological slides of control tissue of Gill (HC-Haemocoelic, SL- Secondary lamella, GL- Gill lamella, L- lining), (H1) Gill exposed to Virtako 3.75 ppm (no change found) ; (H2) 7.5 ppm (arrows shows the reduced haemocoelic and gill lamella), (H3)15.00 ppm (arrows shows erosion of gill lamella).

The histological analyses performed in this study suggest a positive relationship between the pesticides and the occurrence of histological alteration in various organs of crab. Many workers have employed this tool in the study of aquatic pollution. Vernberg and Vernberg (1972) have observed changes in the gill tissue of crab after exposure to sublethal concentration of mercury. Ghate and Mulherkar (1979) have studied the changes in the gill tissue of two freshwater prawns *Macrobrachium lamerrii* and *Caridina weberi*, exposed to copper sulphate. Bodkhe (1983) reported histopathological changes in the gills of freshwater crab, *Barytelphusa cunicularis* following exposure to some pesticidal pollutants (sevimol). In the present study, Morte 48 EC (Chlorpyrifos) showed high toxicity and changes in the general feature of ovaries, gill, testes and stomach. Several previous studies on the histological effect of pesticide confirm the toxicity of chlorpyrifos and its harmful effects in different crab species (Narra *et al.*, 2012). Histological changes in the gills of fishes due to pesticides and other contaminants have been reported by several authors (Dutta *et al.*, 1989). In case of gills Morte 48 EC causes hyperplasia (0.8ppm) and sometimes swelling in gill filaments (0.2 ppm and 0.4 ppm). Since the gills are the primary route for the entry of pesticide, this organ preferentially discussed here. Gills are the main site for gas exchange, ionic and osmotic regulation, so any histological changes in gill structure produce respiratory

disturbances and electrolytic imbalance. The main uptake of the pesticides via gills plays an important role in the uptake of Chlorpyrifos from the gills via circulatory system of the organism. It leads to high uptake rate in organs highly irrigated such as brain, liver and muscle (Narra *et al.*, 2012). The structure of the gills observed in the present study was well in accordance with earlier reports on different crabs (Joshi, 2006; Jadhav *et al.*, 2007). Crab *Barytelphusa cunicularis* exposed to lethal concentrations of mercuric chloride exhibit histological changes in the gills due to the accumulation of mercuric chloride within the organism body producing histological lesion in the body.

In case of ovaries the histological observation showed that there was hyperplasia on ovary of crab due to exposure to different concentration of Morter 48 EC. Crab exposed to concentration of lower dose (0.2ppm) showed mild hyperplasia, but at higher dose (0.04ppm and 0.08 ppm) showed severe hyperplasia. According to Kharat *et al.* (2011) there was a destruction of epithelial layer, degeneration of oocyte and disorganization of nucleus after treatment with 0.26 ppm of Morter 48 EC. There was maximum number of degenerating oocyte with disintegrated nuclei and vacuolization and alteration in shape was observed for 0.09 ppm. (Kharat *et al.*, 2011). The present results are in agreement with the result of Reddy *et al.* (1994) who observed the same effect the ovarian tissue of freshwater crab, *Scylla serrata*, after exposure to cadmium. Sarojini (1990) reported changes in the normal structure of the ovary in freshwater crab, *Barytelphusa guerini* due to zinc sulphate. Bhagylakshmi *et al.* (1984) reported rupturing of oocyte, vacuolization, irregular arrangement of oocyte and disappearance of nucleus were observed in freshwater crab, *Oziotelphusa senex senex* due to sublethal exposure of sumithion.

Epithelial layer destruction, degeneration of oocytes, increased phagocytic cells, vacuolization appearance in cytoplasm and nucleoplasm were observed in TBTCl induced ovary of the prawn, *Macrobrachium kistnensis*, increased exposure leads to increase in damage to the ovary (Kharat *et al.* 2011).

Increased exposure period led to increase in damage to the ovarian tissue; the observed cellular deformities following the cuprous oxide exposure may be due to the direct effects on the developing oocytes through general metabolism and growth, or through hormones controlling ovarian growth (Dode *et al.* 2012). The authors commended that disappearance of nucleus and nucleolus result in the decline of the reproductive activity of *M. kistnensis*. Acute and chronic exposure of mercuric chloride to *Barytelphusa cunicularis* causes several histological lesions in the ovary. The degeneration of oocyte followed by vacuolization in the ooplasm, destruction of membrane and shrinkage of ooplasm was observed after acute and chronic exposure (Shaikh *et al.*, 2010).

In case of testes and stomach similar incident occur during the exposure on different doses of Morter 48 EC. Despite much information available on the histological changes caused by Virtako pesticides, the mode of action on the vital organs is still not fully understood. But according to present study Virtako was less toxic and low histological effect showed in different doses. The histological techniques are the promising area of research in aquatic toxicology as it gives the real picture of the effects imposed and the involvement of the xenobiotics in either disturbing or destroying the vital organs of living organisms. Many researchers have reported the degenerative changes in selected tissues of the animals in response to pollution by various toxicants (Shanmugam *et al.*, 2000; Suresh, 2001; Kale, 2002; Reddy, 2005; Tilak, *et al.*, 2005; Andhale, *et al.*, 2011, Mukke, 2012).

4. Conclusion

Pesticide pollution in agriculture field and aquatic ecosystem is a major environmental concern because it subsequently affects all living organisms in the ecosystem. The histological studies not only give an early indication of pollution hazard, but also provide useful data on nature and degree of damage to cells and tissues. It is a common tool for determining the deleterious effects of toxic substances in animals. According to this

study we can say that Virtako is one of the eco-friendly pesticides, whereas the use of Morter 48 EC in various agriculture fields should be control.

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EFFECTS OF ENVIRONMENT ON AUTISM SPECTRUM DISORDER: A SYSTEMIC REVIEW

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Abstract

Autism Spectrum Disorder (ASD) is an emerging crisis because the children affected by ASD increased in a large number recently. Recent evidences show that up to 40% -50% ASD is influenced by different environmental factors specially the environmental toxicants. In the present paper we conducted the review and analysis of the related literatures. The objective of the study is to find out the more significant relation of environmental factors with the ASD. The review is mainly focused on the relative effect of environmental risk factors on Autism spectrum disorder from preconceptional, gestational and early childhood periods. For the quality and evidence of the review, each literature has been assessed thoroughly and arranged this report in the following category depends on different factors of environment linked to ASD like physical, chemical, biological and social environmental factors. A literature search of online database has been performed from July 2016 and the majority of the study found an association between ASD and different environmental factors. Most of the studies are case-control retrospective study. The toxicants that are related to study were heavy metals, agriculture pesticides, air and water pollutants, industrial chemicals and parent's social relations etc. On searching over 500 databases from online, it is found that about 70 literatures are closely related to reported study. Of these, heavy metal poisoning, exposure to agriculture pesticides, ambient air pollutions, prenatal and perinatal exposure to occupational chemicals, traffic air pollutions, and certain chemical exposures are severely linked with the ASD. But further advance study is needed to find out the exact cause of ASD.

Keywords: Autism spectrum disorder, Environmental factors, Pollution, Environmental toxicants

1. Introduction

Autism Spectrum Disorder (ASD), commonly referred to as Autism, is a complex neuro developmental disorder caused by a combination of genetic and environmental influences. ASD is characterized in varying degrees. The term "spectrum" in ASD refers to the wide range of symptoms and severity. The common characteristics of the people with autism are, ongoing social problems that include difficulties in communicating and interacting with others, repetitive behaviors as well as limited interests or activities and having overly focused interests, such as with moving objects or parts of objects. According to the Autism society of United States of America the Centers for Disease Control (CDC) updated the incidence rate of autism among eight years old is an estimation of 1 in 59 children were living with Autism diagnosis. Symptoms of ASD that typically are recognized in the first two to three years of life. Epidemiologic studies indicate that the number of cases of autism is increasing dramatically each year (Dietert *et al.*, 2011). ASD has emerged as an increasing social concern just as it has increased in prevalence in recent decades. In a large population-based study, the estimated ASD prevalence was 2.47% in US children and adolescents in 2014 to 2016 (Xu *et al.*, 2018).

The exact causes of autism are unknown but the researchers found genetic and environmental factors have relation with ASD but the genetic contribution to the etiology is unknown. The Environmental toxicants have

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effects on central nervous system. Early exposure to toxicants or prenatal and perinatal exposure to environmental factors may affect the neuro development process which may lead to many childhood diseases. Also birth complications, trauma during or after pregnancy and lack of oxygen shows strong link with ASD.

These condition affects the development of central nervous system of child and that makes the child to reveal different behavior than a normal child. Chemical factors such as traffic-related air pollutants; physiological factors including advanced parental age, preterm birth, low birth weight, hyperbilirubinemia and clustering of pregnancy complications and maternal immigrant status are associated with ASD (Ng *et al.*, 2017)

Several studies related to ASD and environment is underway. However, our study found the relation between ASD and environmental factors in different conditions and places. This review will help to find out the more relevant effects of environment in relation to ASD. In Bangladesh ASD is one of the major concern that found in a wide range among children now a days. A 2013 pilot study in Bangladesh, utilizing community health workers, has found prevalence of all kinds of neuro developmental disability is 7.1%. Whereas, for ASD, the study indicates a prevalence of 0.15% (3% in Dhaka city and 0.07% in rural area) (Centre for research and information). In a disability detection survey at 2014-2015 there were 45,236 persons enlisted as Autistic (Disability information system, Ministry of Social Welfare, Bangladesh).

2. Materials and Methods

The online database was searched since July 2016. The search keywords like, 'Effects of environment on Autism spectrum disorder', or 'Effects of Environmental toxicants on Autism' and 'Autism and Environment'. Most of the searching was initiated to the 'PubMed' and 'google scholar' and other search engines. To identify the article, researchers used the search term like 'autism', 'autistic', 'ASD', 'Environment and Autism', 'Environmental toxicants' in all combinations with the terms 'toxicant', 'toxin', 'metal', 'mercury', 'lead', 'chemical', 'pesticides', 'polychlorinated biphenyl (PCB)', 'phthalate', 'solvent', 'pollutant', 'pollution', 'xenobiotic' and 'detoxification.' The references cited in identified publications were also searched to locate additional studies and review articles. From those publications, the relation between environmental effect and ASD was reviewed. A total 77 articles found regarding ASD and environmental effects and 62 articles were evidenced significantly that there are effects of environmental factors on ASD. Among those 62 articles we found 49 articles are strongly related to the environmental effects on ASD. Most of the searches were limited to the literatures published from 2010 to 2018, few literatures published before 2010 were reviewed because of strong evidence related to ASD.

3. Results and Discussion

The review reported wide range of scope for linking environmental toxicity and ASD. Worldwide data has been taken for the comparison and best outcome measures. Each type of risk factor has been discussed which was found from the review of literature related to ASD. Researchers found the following number of articles related in terms of different environmental factors related to ASD.

Table 1. Number of literatures found related to different environmental factors

Environmental factors	Number of reviewed articles
a) Physical factors	23 articles (Air pollutions)
b) Chemical factors	8 articles (Heavy metal, phthalate, Pesticides, certain drugs, Toxic elements)
c) Biological factors	3 articles (Herpes simplex Virus, Other certain viruses)
d) Social Environmental factors	4 articles (Physical and mental stress, behavior, Parents age, Pregnancy Interval, diet)

Each article reviewed thoroughly to find out the relation between Environment and ASD.

Pie chart showing the contains of article's in term of different environmental factors

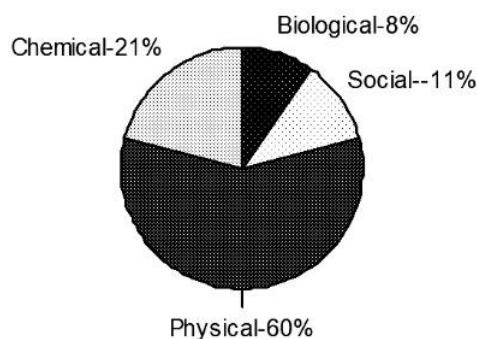


Figure 1. Shows a scenario of reviewed literatures dependent on environmental factor related to ASD.

3.1. Environmental Risk Factors

Karimi *et al.* (2017) reported strong evidences equally for genetics and environmental factors are associated with the risk of Autism spectrum disorder. Kim and Leventhal (2015) found that environmental exposures during pregnancy could cause or contribute to autism based on the neurobiology of the genes are high levels of heritability. Recent twin study found larger environmental influences on ASD risk - 37% heritability and 55% shared environmental liability. Hallmayer *et al.* (2011) reported that toxic chemicals may cause injury to the development of human brain either through direct toxicity or interactions with the genome. Landrigan *et al.* (2012) found that US National Academy of Sciences (NAS) estimated that 3% of neuro behavioral disorders are caused directly by toxic environmental exposures and other 25% are caused by interactions between environmental factors and inherited susceptibilities and epigenetic modification of gene expression by toxic chemicals affects DNA methylation, histone modification or changes in activity levels of non-protein-coding RNA.

Rossignol *et al.* (2014) found in their studies that nutrients, smoking, alcohol, medications and pesticides are the most commonly examined exposures during pregnancy. Due to their known neurotoxicity and/or specific adverse/protective impacts on developing brains. Epigenetics (long-term and/or heritable changes in function of a locus/chromosome without alteration of underlying DNA) may represent one pathway for GxE. ASD is associated with Fragile X, Retts, and Angelmans syndromes, each of which involves epigenetic mechanisms.

Goines and Ashwood (2013), Ramasamy *et al.* (2013), Tordjman *et al.* (2014), Kinney *et al.* (2010) found in their studies that cytokine imbalance can be influenced by environmental pollutants which have an effect on ASD, cytokines are intricately involved in neurodevelopment and neuronal function so cytokine may influence the neuro development of child which may cause ASD. They also found that mercury, cadmium, nickel, vinyl chloride, and trichloroethylene are associated with increased risk of vitamin D deficiency and vitamin D deficiency is found to be one of the risk factor of ASD because it increases the mutation rates.

3.2. Air Pollutions

Volk *et al.* (2011) found that Exposure to Transient receptor potential (TRP), NO₂, PM_{2.5}, and PM₁₀ during pregnancy and the first year of life was associated with autism. They found that local estimates of TRP and regional measures of PM_{2.5}, PM₁₀, and NO₂ at residences were higher in children with autism. The magnitude of these associations appears to be most pronounced during late gestation and early life, In the study researchers found that children with autism were three times exposed during the first year of life to higher modeled traffic related air pollution as compared with typically developing controls and residential proximity to a freeway during the third trimester is associated with ASD. Residence within 309 m of freeways during third trimester of pregnancy is linked with ASD. Tran *et al.* (2013) reported that maternal smoking is not related to autism spectrum disorder.

Becerra *et al.* (2013) found in their studies that ambient air pollution has positive link with ASD. The study was done at Los Angeles city of United States. Ambient gas like CO, NO, NO₂ is linked with ASD. In the second trimester of pregnancy the effects of CO, NO, NO₂ was found more severe than first and third trimester of pregnancy.

Burstyn *et al.* (2011) reported that Lack of oxygen which is called hypoxia at birth have strong relationship with ASD. In the study 480 of 49,165 full-term male births with data on hypoxia were diagnosed with ASD during the follow-up (observed rate 0.98%). Among 8,286 males hypoxic at birth, the observed rate of ASD was 1.03%. Raz *et al.* (2015) reported that higher maternal exposure to PM_{2.5} during pregnancy, particularly the third trimester, was associated with greater odds of a child having ASD.

Lam *et al.* (2016) found in their study that there is strong relation between prenatal exposure to particulate matter and Autism Spectrum Disorder. Li *et al.* (2017) reported that they found a link between postnatal exposure to ambient PM_{2.5} and the onset of ASD-like symptoms in human beings, and the increased inflammatory response and abnormalities in the brain may contribute to the mechanisms of PM_{2.5} exposure-induced ASD.

3.3. Heavy Metal Exposures

Stamova *et al.* (2011), Mostafa and AL-Ayadhi, (2011), found in their studies that exposure to mercury may lead to ASD because mercury have effects on neurodevelopment process and also different genetic transcriptional programs associated with mercury and blood mercury levels were elevated in some autistic children and they were significantly associated with the production of serum anti-MBP auto-antibodies in a group of autistic children. But the literature also reported that mercury released from thimerosal have no relation with autism.

Schultz (2010) reported that the mercury exposure from Environmental source have relation to ASD also mercury used in dental amalgam for pregnant mother also have relation with ASD. Becerra *et al.* (2013), Geier *et al.* (2012) found from their studies at United States that Perinatal exposure to air pollutants may increase risk for ASD. The study focused on use of diesel, lead, manganese, and cadmium, and an overall measure of metals were found significantly associated with ASD.

Adams *et al.* (2013) reported that children with ASD have higher average levels of several toxic metals, and levels of several toxic metals are strongly associated with variations in the severity of autism.

3.4. Chemical Exposures

Landrigan (2010) reported that exposures to certain chemicals like lead, ethyl alcohol and methyl mercury is linked to ASD. But the most powerful proof-of-concept evidence derives from studies specifically linking autism to exposures in early pregnancy—thalidomide, misoprostol, and valproic acid.

Christensen *et al.* (2015) found from their studies that prenatal exposure to valproate may increase the risk of autism usually valproate is used for the treatment of epilepsy and other neuropsychological disorders. Kubota and Mochizuki (2016) reported from their studies that environmental toxicity may affects endocrine disrupting chemicals and mental stress in early life which can change epigenetic status and gene expression which causes ASDs. Parker (2017) found in his study that children who used acetaminophen at age 12 to 18 months were more than eight times as likely to be linked with ASD.

Testa *et al.* (2012) reported that prenatal plus postnatal phthalate exposure may have synergistic and cumulative actions affecting brain development, thus possibly contributing to the ASD.

3.5. Pesticides Exposures

Shelton *et al.* (2012) found in their studies that agriculture pesticides are linked with ASD. Among those studies, one observational and experimental research study reported that use of certain pesticides may increase the risk of ASD specially to the pregnant women. Certain pesticides may decrease the blood oxygen which

causes oxidative stress. Shelton *et al.* (2014) found in their studies that ASD is linked with neuro developmental disorders with gestational pesticide exposures, particularly organophosphates, and pyrethroids and carbamates.

3.6. Biological Factors

Fox (2017) reported in his research that infections during pregnancy may cause some cases of ASD. Hughes, (2011) reported in his article that viral infection may have a link to ASD. Wadman (2017) reported that herpes simplex virus type-2 (HSV-2) has a link with ASD because infected mother's vigorous immune response cross the placenta and damage the fetal brain by the inflammatory molecules and antibodies generated by HSV-2.

3.7. Social Environmental Factors

Fox (2017) found strong evidence in her study that increasing incidence of autism is largely due to sociological factors rather than a true increase in the incidence of autism. Liu *et al.* (2010) found that children living very close to a child previously diagnosed with autism are more likely to be diagnosed with autism. An underlying social influence mechanism involving in this process. Hultman *et al.* (2011) found in his study that paternal age is a risk factor for autism.

Agudelo *et al.* (2016) reported that short inter pregnancy intervals (IPIs) are associated with a significantly increased risk of ASD and long inter pregnancy intervals (IPIs) also appear to increase the risk of ASD.

3.8. Overall Review

From the review study researchers found many environmental factors are linked with ASD. Most effects occur due to environmental pollutions. To reduce the risk of environmental effects on human and living thing we shouldn't disturb the environmental balance and ecosystem. Also, we should try to keep our environment clean. Toxic effects on human body will be reduced if we could reduce the air, water and other environmental pollutions.

3.9. Bangladesh Perspectives

In Bangladesh the environmental pollution is an emerging issue because of rapid urbanization, industrialization and lack of public awareness. Huge use of agricultural pesticides and chemicals on different foods are revealed as a dangerous threat for the human health. We all should be aware of these problems.

3.10. Conclusions

From this review study, researchers found that environmental factors are strongly linked with ASD. Most of the literature strongly focused on the environmental factors which contributed the link to ASD. Different environmental toxicants play key role on ASD, specially from this study researchers found that physical factors are more associated. However, the level and severity of ASD depends on the nature and types of toxicity, gestational age, trimesters of pregnancy, conception and the repeated exposures. Others factors such as parental age; child's weight also should take into account during investigations. For more strong reviews history of parents and child before and after birth is needed in details. Further study is needed to determine the exact cause of ASD related to environment.

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MORPHODYNAMICS OF JAMUNA RIVER ALONG SARIAKANDI UPAZILA, BOGRA DISTRICT DURING 1956-2015

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Abstract

River bank erosion is a perennial problem and has direct impact on the people who are living along the Jamuna river bank area. The studied area about 412 km² lies in north-western part of Bangladesh under Sariakandi Upazila, Bogra District. The present works aim mainly for river shifting detection and morphodynamics analyses of the Jamuna River at Sariakandi Upazila, Bogra District. The area has been classified into 10 geomorphic units. These units are Flood plain, Abandoned channel, Meander scar, Back swamp, Point bar, Old channel bar, New channel bar, Ox-bow Lake, Ephemeral channel and Perennial Channel. The river continuously have been changed its course from East to West since 1956 to 2015. Interpretations of the images data and Topographic map shows that since 1956 to 2015, total 124.77 Km² land area engraved by the river in western bank of the river. On the contrary, in eastern bank about 61.58 km² new land accreted. Highest rate of erosion in between the year of 1956 and 1975 was 6.36 km² per year. Mid channel is now becoming to the main channel and enormous land is expected to be added to the mainland with the sedimentation in the left bank. The widening of the river suggests that channel adjustment is still continuing.

Keywords: Morphodynamics, Shifting, Erosion, ArcGIS

1. Introduction

The Jamuna is one of three large sand-bed rivers that cross the low-lying deltaic floodplain of Bangladesh (Ashworth, 1996). It is provided to have exquisite bank erosion and highest rate of bank line movement (Khan et. al., 2003). The river erosion, bar and bank shifting has direct impact on the people who are living in the river bank area. The study area lies in north-western part of Bangladesh under Sariakandi Upazila, Bogra district. It lies between latitude 24°44'N and 25°04'N and longitude 89°36'E and 89°46'E. The total studied area is about 412 km². Purpose of the present study is to prepare the geomorphological and decade interval bank and bar shifting map and to estimate the decade interval accretion, erosion of bank and bar since 1950's. The work was carried out based on Topographic map and multispectral satellite image analyses since 1950's up to recent period followed by field investigations. The river continuously have been changed its course from East to West since 1956 to 2015.

2. Materials and Methods

The research work was based on multispectral satellite imagery (SPOT, 1990; Landsat-MSS, 1975; Landsat-TM, 1980; Landsat-ETM, 2000; Landsat-ETM+, 2005 & 2015; Rapid Eye, 2010 and Google Earth data) interpretations which were used by means of ArcGIS and Erdas Imagine software followed by field check. Firstly, a base map is prepared by analyses of topographic map (1956) and different satellite images. On the basis of texture, tone, association, shape, pattern, the geomorphological map is prepared. Auger drilling data is carried out from different places to collect the lithological data. Different derivatives maps have been used to prepare morphometry study, bank-bar shifting study etc. Finally, the layers of maps which extracted from different images overlay to obtain the erosion rate.

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3. Results and Discussion

On the basis of geomorphology the area is divided into 10 geomorphic units (Figure 1). These units are Floodplain, Abandoned channel, Meander scar, Backswamp, Point bar, Old channel bar, new channel bar, Ox-bow Lake, Ephemeral channel and Perennial Channel. The overall lithology is classified into three major parts. The upper part mainly composed of clay, silty clay, silty sand, sandy silt and fine sand. The middle part composed of fine to medium sand and basal part composed of coarse sand, pebbly sand and gravelly sand. Borehole lithology signify that the environment near the present channel fluctuate frequently.

The Jamuna River bank of the area is severely affected by erosion. Erosion is influenced by water flow velocity, bank sediments composition and compaction, vegetations and anthropogenic activities. It is evident from the field study that bank eroded mainly by two ways. These are bank scour and mass failure. This loose (lower density), unconsolidated sediments are easily eroded by water flow. Some Unions like Kazla, Chaluabari totally engraved by the river and other Unions like Chandanbaisha, Hat sherpur worstly affected by erosion and still the bank is shifting to westward.

The Jamuna is showing adventurous and violent behavior by its bank erosion rate (Klaassen, 1992). The behavior of the Jamuna River is dynamic and morphology of river changes continuously because there is no certain direction of deposition and erosion. It washed away thousands of hector land used for farming and habitation. The flow of the river varies over a wide range of magnitude. During the period of 1956 to 2015 total 124.77 km² land area engraved by the river (Figure 2). Jamuna River was flowing then along the western part of the Jamalpur District. The river area was 185.94 km² in 1956 and it reaches 301.98 km² in 2000, since then it becomes almost stable (Table 1). Since 1995, the old bar had begun to convert land in left bank of the river. In the period of 1995 to 2015, 61.58 km² old bars converted to land in the left bank of the river. The bar area was highest in 2000 and lowest in 1956. Considering the erosional rate, highest rate was in between the year of 1990 and 1995 which was 3.34 km² per year (Table 2).

Table 1. Morphomerty of Jamuna River in Sariakandi Upazila, Bogra District since 1956 to 2015

Year	Area in Sq.km.						Bar area %
	River reach	Old bar	River	New bar	Old bar to Land	Bar area (Old and new bar)	
1956	185.94	30.47	68.85	86.62	-	117.09	62.97
1975	250.54	79.4	89.64	81.5	-	160.9	64.22
1980	268.19	80.79	89.86	97.54	-	178.33	66.49
1990	272.84	58.89	102.22	111.74	-	170.63	62.54
1995	292.24	115.87	84.63	70.6	21.14	186.47	63.81
2000	301.98	81.15	88.84	109.92	22.07	191.07	63.27
2005	304.59	47.63	93.00	93.88	70.07	141.51	46.46
2010	309.12	66.11	78.91	102.8	61.3	168.91	54.64
2015	309.14	95.77	70.36	81.43	61.58	177.2	57.32

Historically and geologically the Jamuna is the youngest River of the world (Archana *et. al.*, 2012). Because of natural phenomenon like flood and tectonic movement Brahmaputra river started it's flow through a new course known as Jamuna from 1787 (Uddin *et. al.*, 2011). Up to the eighteen century, Jamuna River followed East of Madhupur Tract and then changed it course to run west of it (Schmuck *et al.*, 2001). According to Coleman (1969) the Jamuna has developed by augmenting sediment load and discharge, from a meandering to a braided river. Erosion has taken place preferentially on the west bank. Since 1830, most of the west bank has retreated by 2-4 km (FAP 16+19, 1993). The continued widening of the river suggest that channel adjustment is still

continuing. The unconsolidated sandy and silty Jamuna sediments provide little resistance to such erosion. In dry period river flow is sufficiently rapid where it impinges directly against river-banks to cause slumping of the bank. If the bars are not quickly eroded, they grow by accretion of sediments during subsequent flood seasons. Accretion may occur at the upstream end, on one or both sides, or at the downstream end (Brammer, 2002). The rate of bank erosion and channel widening appear to have increased in recent times. The analyses carried out since 1956 to 2015 (Figures 1 to 4). The interpretations of the data shows that since 1956 to 2015 total 124.77 km² land area engraved by the river in western bank.

Table 2. The table showing the engulf area and rate of erosion since 1956 to 2015.

Year Interval	Engulfed area (km ²)	Rate of erosion
1956 to 1975	63.57	3.34
1975 to 1980	15.91	3.18
1980 to 1990	6.29	0.63
1990 to 1995	19.14	3.83
1995 to 2000	10.20	2.04
2000 to 2005	2.93	0.59
2005 to 2010	4.52	0.90
2010 to 2015	2.21	0.44

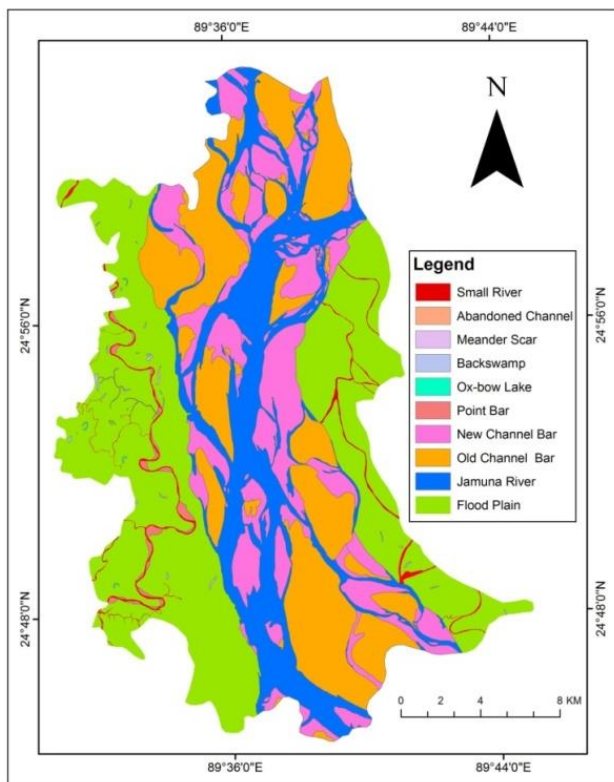


Figure 1. Geomorphological map of study area.

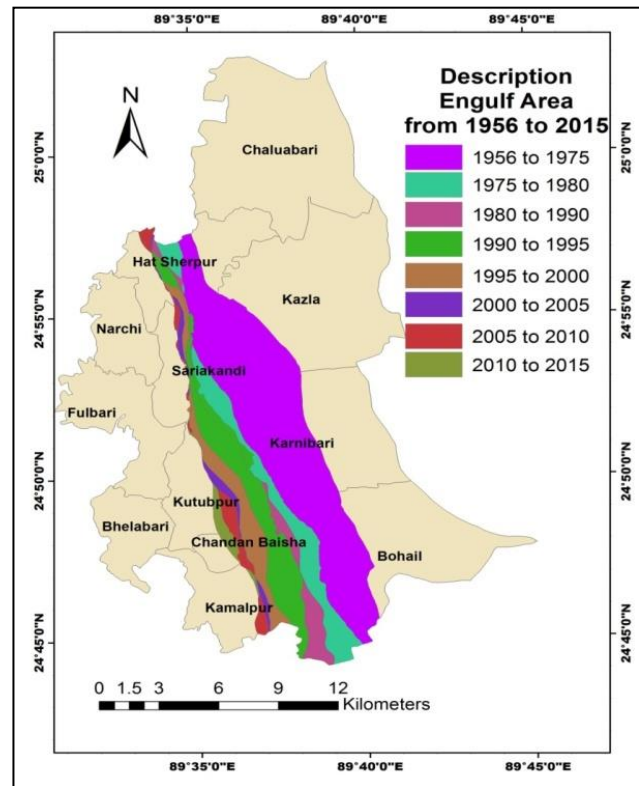


Figure 2. Year interval engulf area since 1956 to 2015.

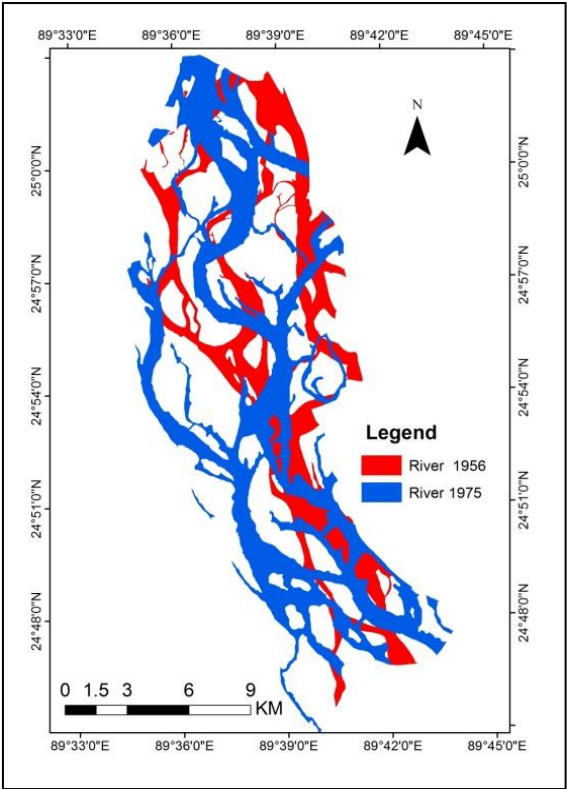


Figure 3. Jamuna River shifting map in Sariakandi Upazila, 1956-1975.

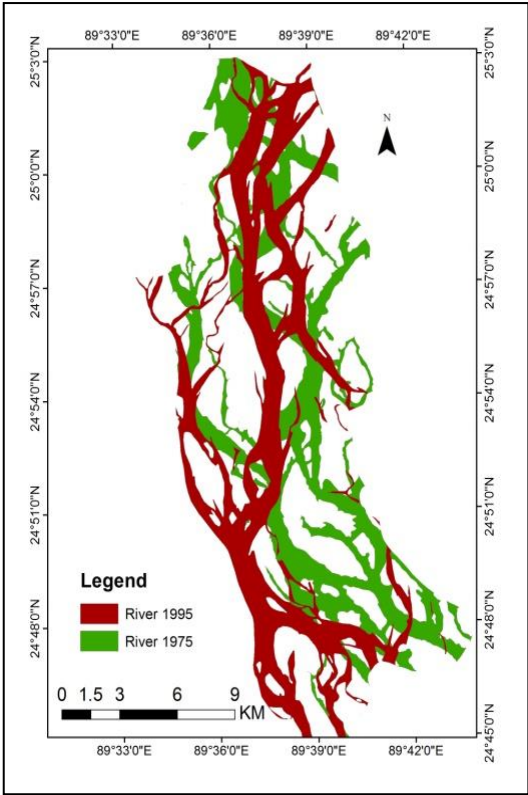


Figure 4. Jamuna River shifting map in Sariakandi Upazila, 1975-1995.

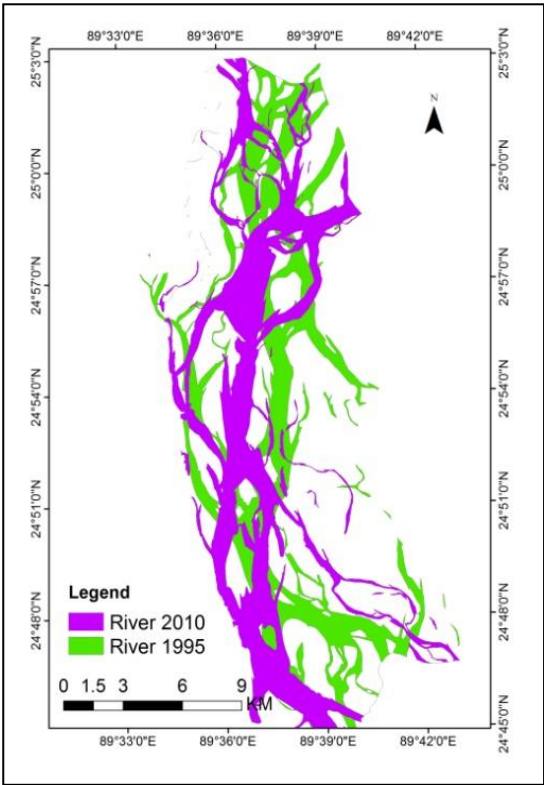


Figure 5. Jamuna River shifting map in Sariakandi Upazila, 1995-2010.

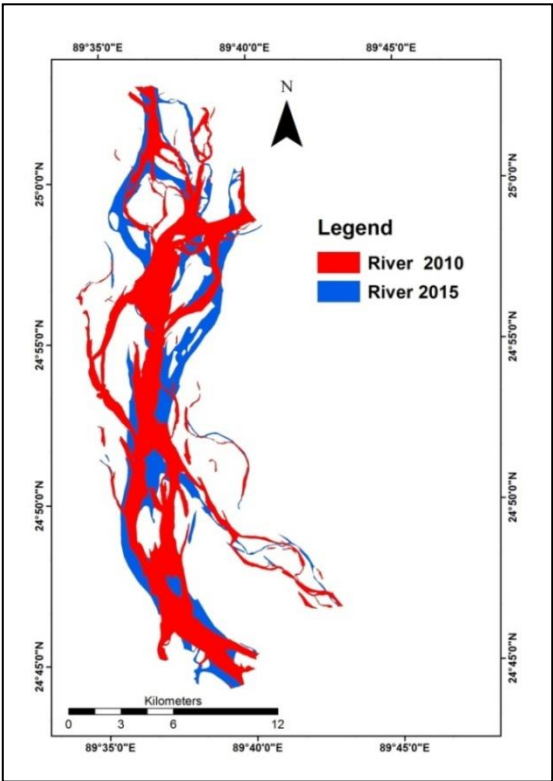


Figure 6. Jamuna River shifting map in Sariakandi Upazila, 2010-2015.

In the studied area, since the middle of 19th century, trend of the river course is shifting continuously to westward. Thousands of people had been changed from land owners to refugees during this period for river shifting. Interpretations of the images data and Topographic map shows that since 1956 to 2015, total 124.77 km² land area engraved by the river in western bank of the river. On the contrary, in eastern bank about 61.58 km² new land accreted. Mid channel is now becoming to the main channel and enormous land is expected to be added to the mainland with the sedimentation in the left bank. Left bank of the river in study area may call “the place of newly accreted landmass” once which was the place of erosion. Now the main river is flowing along the eastern part of the Sariakandi Upazila. The output of the present research work may be helpful to the decision makers to take the proper mitigation measure regarding river bank erosion. The area should be kept in government authorities’ attention to take preventive bank erosion measures considering the river geomorphology and morphometry. Right bank should be protected by permanent bank protection schemes, so that, further westward devastating shift can be avoided in future.

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SOCIO-ECONOMIC IMPACT AND COPPING WITH RIVERBANK EROSION: A CASE STUDY OF KAZIPUR UPAZILA, BANGLADESH

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Abstract

This research is designed to explore the erosional pattern of the river Jamuna and its socio-economic impact on dweller's livelihoods and their adaptation strategies of the two villages of Kazipur Upazila under Sirajgonj District. Riverbank erosion makes many unavoidable problems at different phases of displacements. It compelled the victims to rearrange all their activities related to livelihood pattern and adapt with a new socio-environmental situation. To adapt with a new settlement, they had limited choice of their own. Rather they were compelled to immediately search for their shelter, food and other essential needs. Most of displaces settled in nearby safer places firstly and then set up their final destination. In the process of displacement and re-settlement as a strategy of adaptation, the number of family members changes followed by changes in family structure, monthly income, expenditure capacity, savings, as well as their social status and security. With the prevailing policies and programs undertaken by governmental and non-governmental organizations a lot can be done to save and improve their lives, assets and livelihoods. From this point of view, river bank erosion has to be considered as a unique disaster, and utmost need to take comprehensive riverbank erosion management policy.

Keywords: Riverbank Erosion, Displacement, Indigenous coping, Jamuna River, Bangladesh

1. Introduction

Bangladesh is the largest delta in the world, situated at the confluence of the Ganges, Brahmaputra and Meghna Rivers. There are about 750 rivers in this country (Banglapedia, 2006). This huge number of river creates different types of natural disasters such as flood, riverbank erosion etc and among them riverbank erosion is considered as vital one. It is estimated that at least 1 million people are being displaced due to riverbank erosion in the country every year (Elahi and Rogge, 1990). This adversity would be worsened further when the devastating erosion throughout the country makes the millions of people homeless every year and causing alarming socio-economic impact. It is also reported that the riverbank erosion has intensified the process of pauperization in affected areas of Bangladesh (Karim, 1990; Rahman, 1986; Jahangir, 1979). However, 75 of 750 rivers in the country are favorable for erosion (BWDB, 1999). Besides, among 64 districts 241 regions of 58 districts are affected by erosion. The displacees are forced to formulate various indigenous strategies for coping to the unsafe riparian changed environment devoid of organizational support. It is disappointing fact that the land and population displacement due to riverbank erosion in Bangladesh has received no special attention either by social scientists or by the government (Zaman and Wiest, 1985; Islam, 1995; Abrar and Azad, 2004; Rahman, 1986; Chowdhury and Kabir; 1991; Halli, 1991; Haque, 1991; Mahbub and Islam, 1991; Rogge, 1991).

To adopt with the situation taken steps are inadequate as compare to the needs of victims (Hossain and Greenberg, 1985). The study attempts to explore the trend of riverbank erosion and deposition of the study area and to assess the impact of riverbank erosion on socio-economic condition of the stakeholders and find out the strategy for mitigation and coping with it.

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sample size, 92 from Bilchotol and 80 from Patagaon have taken for collecting data. To analyse, tabulation and graphic representation SPSS software and mapping analysis ArcMap ArcInfo software have been used.

3. Results and Discussion

3.1. Riverbank Erosion and Deposition Pattern

Different studies on the Jamuna River show that the channel processes in the Jamuna River are quite rapid and generally associated with erosion and deposition of river bed. Such a quickly responding river with comparatively low bed load transport, whose processes of sediment transport i.e. the bed, near-bed or suspended load transport activate the changes of river bed left a question to the model morphological processes of the river.

The maps in Figure 2 depict the erosional and depositional trend of the river Jamuna. In 2007, the area of the river in Kazipur Upazila was 120.54 sq km and after 7 years the area of this river become 66.07 sq km. It is alarming that the area of riverbank have increased 54.57 sq km. By this time, only 17.85 sq km land has gained by the depositional process of the river Jamuna. If the erosional process at the same rate of the Jamuna River continues Kazipur Upazila will be added into river channel of this river within a short time.

4. Impact of Riverbank Erosion

Specific dimensions of social, economic and political vulnerability are related to inequality, gender relations and economic patterns of any community. The level of risk in relation to natural disasters in a society is, thus, determined by the levels of vulnerability, combined with the level of probability of the occurrence of natural hazard (flood, drought, erosion, landslide, earthquake, volcanic eruptions, storms and cyclones) as well as the level of and intensity of such a hazard (Ashley *et al.*, 2000). Riverbank erosion has socio-economic impacts which are discussed below into two broad categories.

4.1. Social Impact

4.1.1. Impact on Family Structure

Riverbank erosion has a crucial impact on riparian inhabitants. It affects almost all the social condition of the society of the study area. Family is the initial and primary important unit. It is a significant social institution. The type of family depends upon the composition of its membership pattern which also varies from one society to another or even within the different segments of the same society. A nuclear family refers to parents and their unmarried children in a household. A common residence, common property, common worship, a common kitchen and a system of mutual obligation among the different members are the main characteristics of the joint family. However, in most of the cases economic condition of a family depends on the structure of their family. Riverbank erosion breaks the family ties of the affected area. An increasing trend in single family was found during study. In the study area 70.33 percent families become single from 32.85 percent. Whereas in Bilchotol 70.65 percent families become single from 29.44 percent and Patagaon 70 percent families become single from 36.25 percent (Table 1).

Field data analysis indicates that at present in Bilchotol village every family has on an average 3.71 members which was 5.38 members before erosion. And in Patagaon village, at the same, the average household member reduced 3.73 persons from 6.03. Before erosion, at Bilchotol and Patagaon villages 15.22 percent and 10.00 percent household have 3-4 members respectively but these is now 48.91 percent and 55.00 percent respectively. Besides, now in these two villages 3.26 percent and 2.50 percent households have 7 or 8 members and previous time these were 43.48 percent and 35 percent respectively (Table 1).

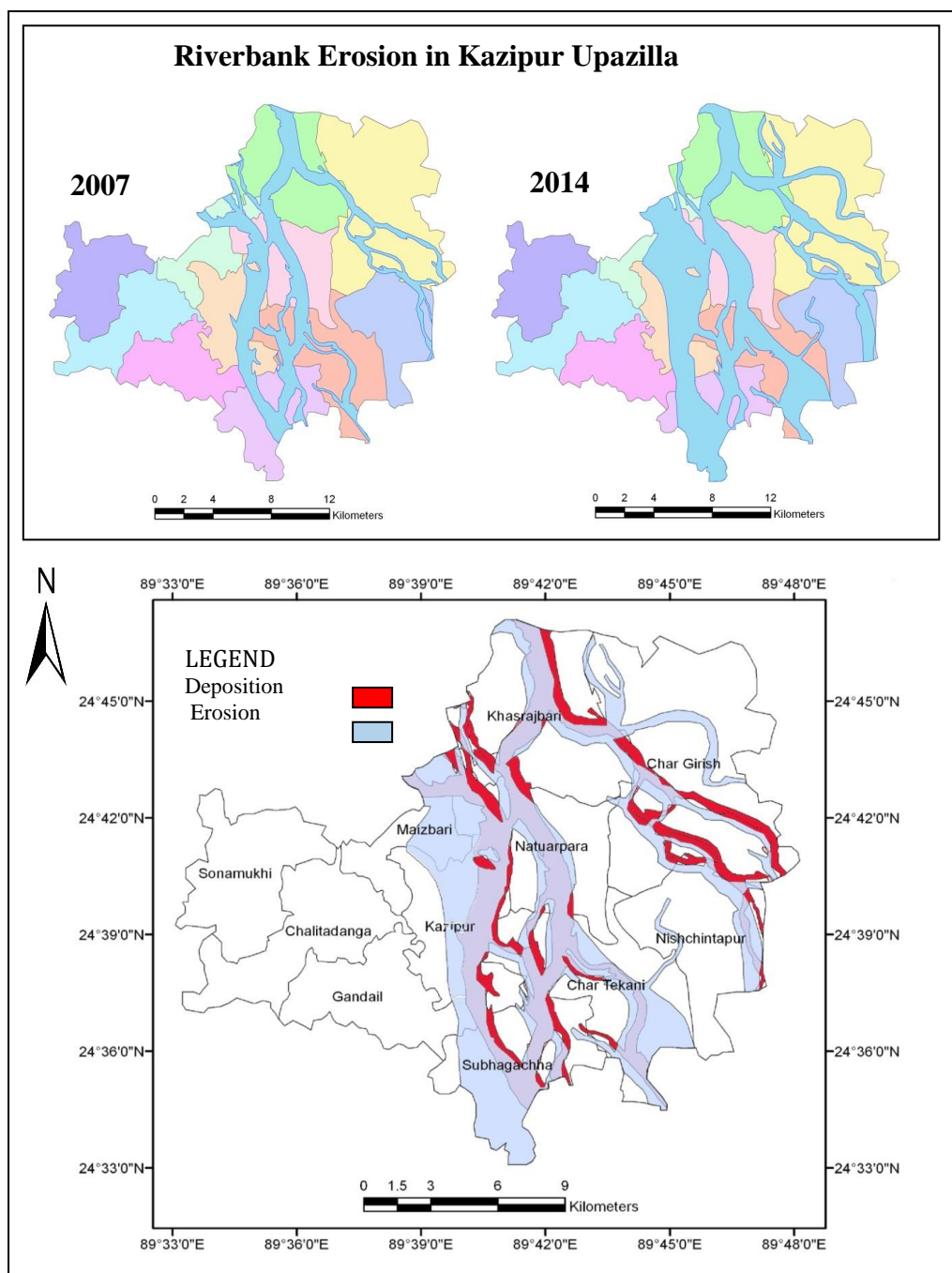


Figure 2. Depositional and erosional process of the Jamuna River in the study area.

4.1.2. Impact on Working Age Population

Population structure of the study area has discussed based on the dependent and independent population. A mentionable number of young and middle aged people have migrated from this locality to another place to lead their livelihood. Before erosion on an average 33.15 percent population was from the age group of 15-34 years, but this figure is 17.82 percent after erosion (Table 1). An apparent comparison of these two sets of data of different time reveals that dependent populations of study area are increasing at an alarming rate that downing living standard of stakeholders.

4.1.3. Impact on Shelter and Housing

Riverbank erosion has an adverse impact on the shelter and housing pattern of the study area. After riverbank erosion the displacees of different adjoining villages located in the riparian tract on the west bank of Jamuna river migrate to many areas and the displacees dislocated on the flood preventing embankment, on neighbors' land, on *khas* land beside the roads and highways, rent house.

Table 1 depicts that now 47.71 percent of sample people live in their own house but before erosion this was 92.36 percent. Besides it has found that 9.43 percent and 21.67 percent of people is living on embankment and along the roadside respectively which was not found before the riverbank erosion. It is also seen that now 18.23 percent people are taking shelters to neighbor's and relative's house but before erosion this was 5.30 percent (Table 1).

Housing condition of an area depends on its geographical settings and life style of the people of certain area. Some areas are suitable for mud made house, some are perfect for corrugated iron sheet and some are good for brick built house. It is found that on an average 1.80 percent of houses are made of thatch and bamboo after erosion and before this was 33.57 percent. Besides, now 64.94 percent house is made of Corrugated Iron Sheet (C.I. Sheet) and wood but before erosion this was 33.92 percent (Table 1). The threat of riverbank erosion impelled them to use movable housing materials. In addition to this fact, many of displacees built movable housing structure because they are not adequate economic solvent for building house by brick and cement.

Riverbank erosion also affects the size of the study area. It can be said from the table that 50.41 percent of sample household have no homestead land but before erosion this figure was 6.38 percent. About 3.50 percent households have the plot of 0.20-0.25 acres but before erosion this was 28.01 percent. The table also presents that 29.76 percent of sample household had a homestead plot of 0.15-0.20 acres but this figure is now 5.76 percent (Table 1).

4.1.4. Impact on Drinking Water Supply and Sanitation

The UN has declared sanitation facility for all by the year 2015. Government of Bangladesh expresses deep concern about the matter and according to MDG and PRSP sanitation for all will be insured by the year of 2015. A large part of the riverbank erosion victim have no own shelter. They make their shelter and latrine for temporary use. So they have not enough money and enough interest to make sanitary latrine. They make unhygienic latrine and use this. Table 1 gives us significant indication that before 48.51 percent people use sanitary latrine but now only 33.26 percent people use this type of latrine. However, it is disappointing that a mentionable part of household have no latrine. They use open space, bank of river and relative's latrine. Their sanitation is alarming in regard to public health in both villages.

Drinking water is the important feature of the way of life. In these two villages tube-well is found as being the dominant source for drinking water supply to dwelling households. Research result indicates that 79.29 percent people drink tube-well water which was 65.8 percent before erosion (Table 1). Research data also indicates that in these two villages people mostly take their drinking water from tube-well. Some household displaced to nearby cities or town and drink the supply water. In Bilchotol village there were three wells and water of two of the wells had eroded and some people drink water from these well.

Table 1. Social impact of riverbank erosion in the study area

<u>Impact on Family Type</u>						
Family Size	Bilchotol		Patagaon		Average	
	At Present (%)	Before Erosion (%)	At Present (%)	Before Erosion (%)	At Present (%)	Before Erosion (%)
Single	70.65	29.44	70.00	36.25	70.33	32.85
Joint	29.35	70.56	30.00	63.75	29.67	67.15
<u>Impact on Household Member</u>						
Members Per Household	3.71	5.38	3.73	6.03	3.72	5.71
<u>Impact on Population Structure</u>						
0-14	31.37	37.38	30.33	36.34	30.85	36.86
15-34	17.01	32.32	18.64	33.98	17.82	33.15
35<	25.23	26.46	23.51	27.32	24.37	26.89
Migrated	26.39	3.84	27.52	2.36	26.96	3.10
<u>Impact on Shelter</u>						
Own House	55.43	93.48	40.00	91.25	47.71	92.36
Rental House	2.17	2.17	3.75	2.50	2.96	2.34
Neighbor's & relative's Hous	15.22	4.35	21.25	6.25	18.23	5.30
Roadside	7.61	0.00	11.25	0.00	9.43	0.00
Embankment	19.57	0.00	23.75	0.00	21.67	0.00
<u>Impact on Housing Pattern</u>						
Brick and Cement	7.61	3.26	10.00	2.50	8.80	2.89
Cement Pillar, Wall, CI Sheet	9.78	4.35	18.75	5.00	14.27	4.68
CI Sheet and Wood	67.39	39.13	62.50	28.75	64.94	33.92
Thatch, Bamboo and CI Sheet	14.13	17.39	6.25	32.50	10.19	24.94
Thatch and Bamboo	1.09	35.87	2.50	31.25	1.80	33.57
<u>Impact on Household Plot</u>						
>0.05	7.61	2.17	10.00	3.75	8.80	2.96
0.05-0.10	19.57	2.17	12.50	3.75	16.04	2.96
0.10-0.15	10.87	7.61	6.25	8.75	8.56	8.18
0.15-0.20	6.52	28.27	5.00	31.25	5.76	29.76
0.20-0.25	3.26	34.78	3.75	21.25	3.50	28.01
0.25-0.30	4.34	7.61	2.50	10.00	3.42	8.81
<0.30	3.27	10.87	3.75	15.00	3.51	12.94
No Own Homestead Plot	44.57	6.52	56.25	6.25	50.41	6.38
<u>Impact on Sanitation</u>						
Sanitary Toilet	31.52	53.27	35.00	43.75	33.26	48.51
Hanging Toilet	58.70	27.17	52.50	38.75	55.60	32.96
Open Space	2.17	14.13	2.50	11.25	2.33	12.69
Others	7.61	5.43	10.00	6.25	8.81	5.84
<u>Impact on Drinking Water Supply</u>						
Tube-well	76.09	73.91	82.50	56.25	79.29	65.08
Tap	8.70	0.00	7.50	0.00	8.10	0.00
Well	9.78	11.96	0.00	20.00	4.89	15.98
Pond/Dighi/River	5.43	14.13	10.00	23.75	7.72	18.94

4.1. Economic Impact

4.2.1. Impact on Land Holding

Agricultural land provides about 90 percent rural population of more than 80 percent of the total population with employment and source of another income upon the rural land resource (Elahi and Rogge, 1990).

Landholding pattern in Bangladesh is based on a system of very uneven distribution. This distribution along with the increasing scarcity of land and increasing population causes a change in the ownership pattern of land.

The Table 2 divulges that 0.54 percent of people are rich peasant (>7.01 acres) but before erosion this was 12.39 percent. Besides, before erosion 16.19 percent people were marginal (<1.00 acre) peasant but at present this is 34.64 percent. Moreover, now 73.13 percent people are landless and before erosion this type of people was 6.39 percent. Landless and marginal farmers require to go on hire for agricultural day labour and/or to do sharecropping to support their family expenses. The lifestyles of landless farmers are very miserable.

Table 2. Economic impact of riverbank erosion in the study area

<u>Impact on Land Ownership</u>						
Category of Peasant	Bilchotol		Patagaon		Average	
	After Erosion (%)	Before Erosion (%)	After Erosion (%)	Before Erosion (%)	After Erosion (%)	Before Erosion (%)
Rich Peasant (7.01 acres<)	1.09	9.78	0.00	15.00	.54	12.39
Middle class Peasant (2.51-7.00 acres)	2.17	13.04	3.75	20.00	2.96	16.52
Poor Peasant (1.01-2.50 acres)	4.35	32.62	10.00	27.50	7.18	30.06
Marginal Peasant (< 1acres)	17.39	38.04	15.00	31.25	16.19	34.64
Landless Peasant	75.00	6.52	71.25	6.25	73.13	6.39
<u>Change in Occupation</u>						
Farming	14.13	59.78	10.00	55.00	12.06	57.39
Sharecropping	13.05	5.43	11.25	6.25	12.15	5.84
Agricultural Labor	14.13	15.22	17.50	16.25	15.82	15.73
Day Labor	8.7	4.35	11.25	3.75	9.97	4.05
Garments Workers	7.61	1.09	8.75	2.50	8.18	1.80
Govt. Service	5.43	2.17	2.50	1.25	3.97	1.71
Non-Govt. Service	5.43	3.26	8.75	3.75	7.09	3.50
Rickshaw/Van Pulling	10.87	1.09	6.25	2.50	8.56	1.80
Fishing	4.35	3.26	3.75	2.50	4.05	2.88
Tailoring	3.26	0.00	2.50	1.25	2.88	.62
Small Business	5.43	2.17	6.25	2.50	5.84	2.34
Carpenter	4.35	1.09	3.75	1.25	4.05	1.17
Others	3.26	1.09	7.50	1.25	5.38	1.17
<u>Impact on Income</u>						
0-1500 taka	22.83	11.96	23.75	15.00	23.29	13.48
1501-3000 taka	18.48	19.57	20.00	16.25	19.24	17.91
3001-4500 taka	16.31	13.04	17.50	18.75	16.90	15.89
4501-6000 taka	17.39	15.22	17.50	11.25	17.45	13.24
6001-7500 taka	13.04	15.22	10.00	13.75	11.52	14.48
7501-9000 taka	5.43	11.96	5.00	8.75	5.21	10.36
>9000 taka	9.52	13.04	6.25	16.25	6.39	14.64
<u>Impact on Saving</u>						
>1000 taka	23.91	40.26	17.75	33.75	21.33	36.98
1000-2000 taka	10.87	16.30	18.75	26.25	14.81	21.28
2001-3000 taka	11.97	11.95	6.25	8.75	9.10	10.35
>3001 taka	6.52	14.13	12.50	11.25	9.11	12.69
No Saving	46.74	17.40	43.75	20.00	45.25	18.70

4.2.2. Occupational Diversification

In the study considered those occupations which principally contribute to the daily survival of the villagers throughout the year. It is very difficult to assess income from each occupation because a household may have more than one occupation. An appropriate investigation of occupational structure of a community usually considered the household as the unit of analysis (Gupta, 1959). In this research primary occupation is considered for analyzing the occupational structure of the victimized households of Bilchotol and Patagaon

village because the occupational trademark of a household is identified by its primary occupation. It is also considered that household head is representative of the household. Victimized people of both villages accept several activities as their primary occupation. Table 2 indicates that before erosion 78.96 percent people were engaged in agricultural occupation like farming, sharecropping and agricultural labor but now this figure is 38.75 percent. Moreover, 61.25 percent people are dependent on non-agricultural occupation such as garments worker, day labor, government services, non-government services, rickshaw/van pulling, fishing, tailoring, small business carpenter etc. but before erosion this figure was 21.04 percent. An apparent comparison of two sets of data reveals a hidden reality that now peoples are involved in many occupations. But before erosion, farming was the most dominant and key activity in both the villages. As the peoples had lost their agricultural land and homestead plot, they have involved in different non-firm occupation.

4.3.3. Impact on Income and Saving

The income of the household heads clearly shows the poverty level of the people. Income is the main and foremost important factor to describe the level of poverty. In this context the study estimates the actual income of households. It is difficult to estimate rural income accurately because most of the households are self-employed and very few household have records of incomes from different sources. Many households are also engaged in expenditure-saving activities such as producing fruits and vegetables in kitchen gardens, rearing poultry and livestock, fishing from common water bodies such as river, creeks, canals and manufacturing personal household goods for consumption of members (Aziz, 2006).

It could be observed from Table 2 That now on an average 23.29 percent households have income below 1,500 taka but before erosion it was 13.48 percent indicating low income people increasing gradually. On the other hand before erosion 14.64 percent household had income above 9,000 taka but now this figure is 6.39 percent. An apparent comparison of these two sets of data of two different times reveals a hidden reality that 10 or 15 years back price of different goods which are used for livelihood was cheap. But at recent time these goods are very costly and it is higher than two or three times. So the real condition of the income is so miserable and it is not possible to lead a normal or standard life. From above discussion it is clear that a mentionable number of members have migrated due to earn their bread. Beside of earning bread they sent a part of income to their parents but it is not enough for living.

Due to riverbank erosion, every household has lost their land and other properties. They have no surplus income and so that they have no available saving. Moreover, overpopulation, high dependent people, frequent natural calamity etc. are not suitable for saving. The Table 2 shows that at present 45.25 percent of sample households have no saving but before eroding period only 18.70 percent had no saving. Similarly, before eroding the riverbank 12.69 percent households could save more than 3,000 taka and now this figure is 9.11 percent. So, it can be said that living standard of life is declining day by day, high income population is entering into low income group resulting losing their saving capacity.

5. Copping Strategies Undertaken by Displacees

The displacees plan and undertake their coping strategies at the individual level, as they are not responded by any organizational sources in this regard. Except erosion prevention measures, they formulate and undertake corrective type of strategies signify purposeful attempts to modify the hazard event or change location, and/or resource use to minimize the hazard loss (Burton *et al.*, 1978). These purposeful strategies are interesting in their features. The displacees generally tended to undertake multiple strategies, as none of those is adequate for their purpose. Their strategies are molded by the situational characteristics of the resource unit and timing of hazard phenomenon (Haque, 1991). The micro-level social, economic and political environment significantly influences the displacees' local adjustment strategies (Zaman, 1989a, 1989b). The victims try to establish a

number of interactions with that environment through some social organizations such as, family, society, neighborhood, etc. The prevailing techniques of coping for the displacees are their riverine culture.

5.1. Preventive Measures

The measures for protecting land and tangible properties against riverbank erosion claim a large-scale technological control of structural-engineering works. It requires organizational responses. Such responses in Bangladesh are confined to the protection schemes of urban and commercial centers. The original homestead places of displacees did not receive any organizational responses. It has been found that more than 31 percent people built bamboo crafts and fences and placed them on the waterfront. The people adopted this strategy in order to protect cultivable land and homestead plot from the cataclysm of erosion-attack. In this strategy bamboo is used in a large scale. It is also found that 59.69 percent people piled sandbags up in preventing riverbank erosion from destroying prodigious land and other tangible properties (Table 3). They have informed that they collected sand in the dry season and reserve it for using in the scheme of preventing. The people of same area undertook their preventive measures in group in order to adapt to that changing environment. Their collective role of manual, economic, social participation in making such strategy is to be worth a great initiative at the community level.

5.2. Preparation for Receiving Damage

The victims of Bilchotol and Patagaon village were compelled to receive their loss due to riverbank erosion. They did not have any alternative choice of loss recovering as they failed in protecting their cultivable land, homestead plot, other valuable properties from the effect of riverbank erosion. Their prevention strategies were found to be worthless and the erosion attack went out of their control. About 40.76 percent of total victim undertook the corrective strategy of land desertion and they accept massive loss caused riverbank erosion. Majority of victims left their original homestead intending ever to return. The victim adopted another measure of loss receiving. They started to pray to God as they found the prevention of erosion beyond their control. About 75 percent victims of Bilchotol and 68.48 percent victim of Patagaon village prayed to God for the prevention of riverbank erosion (Table 3). On the basis of their religious sentiments these strategies have made.

The displacees deserted their original homestead plots. Haque (1991) found in Kazipur that 63 percent of respondents actually abandoned their original homestead plot located on the right bank of Jamuna River and also to move other tangible resources to a nearby safer displacement, they got the change of dismantling and of moving their livestock and properties when the erosion-attack during the season. They left their original place without intending ever to return as they lost their homestead plot fully or partially. The desertion of original homestead plot is an unequivocal acceptance of the erosion induced loss (Haque, 1991).

5.3. Damage Minimization

The displacees of Bilchotol and Patagaon formulated and undertaken some strategies to reduce the economic loss induced by riverbank erosion. A few number of displacees reported that their indigenous technologies of bamboo crates and sandbags are found to be partially effective in protecting their land for little span of time in a season and it is eventually subjected to erosion in the same season or in the next. Field data reveals that 18.48 percent displacees of Bilchotol and 23.91 percent displacees of Patagaon also sold different kinds of tangible valuable assets. It includes ornaments of female members, bicycle, motorcycle, bullock cart, plough, power tiller, furniture, utensils, corrugated iron sheet etc. Displacees of Bilchotol (23.91 percent) and Patagaon (16.30 percent) cut and/or grazed their standing crops from their field subjected to erosion. A mentionable number of these displacees also sold their remaining cultivable land. They procured money through selling these in order to purchase land in comparatively safer places and housing materials for rehabilitation. About 9.78 percent of Bilchotol and 19.56 percent of Patagaon had cut their standing trees and saved it from the attack of riverbank

erosion (Table 4). It can be informed from the field data that the victims of Bilchotol and Patagaon adopted multiple strategies to receive loss, to reduce loss and in shifting their lives and properties due to riverbank erosion.

Table 3. Copping strategies undertaken by the displacees

<u>Preventive Measures</u>			
Categories	Bilchotol	Patagaon	Average
Piling Sandbags	69.56	47.82	59.69
Bamboo Crates	25.00	38.04	31.52
<u>Preparation</u>			
Pray to Allah	75.00	68.48	71.74
Homestead Desertion	44.56	36.96	40.76
<u>Damage Minimization</u>			
Sale of Livestock	20.65	20.65	20.65
Sale of Valuable Asset	18.48	23.91	21.20
Cutting Standing Crops	23.91	16.30	20.11
Cutting Trees	9.78	19.56	14.67
<u>Shifting</u>			
Family Members	100	100	100
Tangible Properties	69.57	71.74	70.66
Livestock	29.35	31.52	30.44
<u>Housing Structure</u>			
Brick and Cement	7.61	10.00	8.80
Cement Pillar, Wall, CI Sheet	9.78	18.75	14.27
CI Sheet and Wood	67.39	62.50	64.94
Thatch, Bamboo and CI Sheet	14.13	6.25	10.19
Thatch and Bamboo	1.09	2.50	1.80
<u>Investment Pattern</u>			
Moveable Properties	15.22	26.09	20.66
Livestock	17.39	10.87	14.13
Land Purchase	11.96	7.61	9.79

Source: FieldSurvey, 2012

5.4. Shifting of Lives and Properties

The shifting of lives and properties from erosion-threatened homestead to a safer place is another corrective strategy undertaken by the displacees of Bilchotol and Patagaon. It is found that 100 percent of the displacees move family, 70.66 percent move livestock and 30.44 percent shift their belongings from erosion-affected regions to comparatively safer places. The collected data depicts the estimated shifting caused by riverbank erosion. It encompasses some measures such as the shift of family members, tangible properties and livestock from erosion affected area to erosion free area. These are dominant measures adopted by the sample population. It has been found that all the displacees of both villages shifted their family members from the affected homestead plots to BWDB embankment, relatives' shed, neighbors' land, *khas* land etc. and to other villages as well.

5.5. Using Movable Housing Materials

The displacees widely use the movable housing materials in constructing their houses on the riparian tract. It is an incidental rather than purposive type of coping strategies (Haque, 1991). The threat of riverbank erosion attack impelled the victims to use movable housing materials. These materials are easily movable and less susceptible to the damage caused by riverbank erosion. A preponderant majority of the displacees (Bilchotol 67.39 percent and Patagaon 62.50 percent) use corrugated iron sheet as material in constructing their houses

(Table 3). The use of corrugated iron sheet is their traditional housing structure. Moreover, the corrugated iron sheet has salvageable, resalable and reusable values.

5.7. Investment Pattern

In the pre-displacement period, the displacees invest their capital in purchasing land in this area, livestock and other movable assets. They purchase the assets purposefully in order to use in vulnerable period. This type of investment is nothing but their precautionary measure to adapt to the precarious environment. It is reported that 15.22 percent displacees of Bilchotol and 26.09 percent of Patagaon purchased movable properties which have re-saleable and reusable values. Similarly the people purchasing of land and livestock is mentionable.

5.8. Clustered Settlement Pattern

The displacees started to resettle themselves closely together. They form a cluster and/or contiguous settlement in the study villages. They were also clustered into a major squatting beside the road and on the flood-preventing embankment (Zaman, 1986).

Their settlement in a cluster and contiguous pattern is a corrective type of strategy for adapting to a new social environment. One's homestead neighbors on others and it helps them to maintain their *samaj* ties. As the *samaj* members they provide help with each other in any emergencies. This is an incidental measure of reducing loss due to riverbank erosion. The clustered settlement pattern builds a bridge between the displacees settled in Bilchotol and Patagaon village. Moreover, they are supported by their non-displacee counterparts in both the study villages.

6. Conclusion and Recommendation

Riverbank erosion is one of the unavoidable natural hazards in Bangladesh. Research results indicate that it has tremendous negative impact on people's socio-economic life. For the study two villages have been considered. It is found that there is no vast difference in respect of socio-economic change and their mitigation strategies between the villages because the villages are situated in the same physiological zone and the victims of both villages face the same kinds of socio-economic problems. Erosion has disastrous social and economic impact on affected people's life like homestead and cultivated land, occupation, earnings, crops, livestock, food, housing materials, population structure, health and sanitation as well as overall life style. The victims of study villages adopted multiple strategies to minimize loss of life and properties. It is found that some people pray to Allah for loss-acceptance, salvaging housing structure for loss-reduction. Sometimes they shifts to nearby or far away new destination with their tangible properties. The strategies of loss-acceptance, loss-reduction and shifting of lives and properties contribute crucially to the process of displacees' environmental adaptation to their precarious habitat caused by erosion. However, the research findings set down some recommendations in order to overcome, better management and cope with the situation these are followings.

Before hazard, government needs to take long-term vision and mission to protect from river bank erosion. At first, government needs to identify the erosional area and based on it to take projects to build up sufficient polders or cross-dams or protection walls to slowdown the flow in order to reduce bank erosion. Sometimes government takes such types of projects to build up but it is insufficient and very often due to corruption the project does not complete timely. As a result, the construction goes to river basin before completing. On the other hand during erosion people use sand bag to protect river bank. Very often these are insufficient. So, government should pay key attention to long term and sustainable construction. Moreover, government can take tree plantation programmes in order to reduce soil erosion as well as river bank erosion.

During hazard, victims face shelter, food, drinking water, cloths and medicine crisis. They take shelter on embankment of river or government institutes like cyclone/flood shelter, schools or any nearby or distant

relative's house. At that time they live on relief of GOs and NGOs. So, government needs to take necessary steps to provide shelter and work opportunities for the victims to cope with the situation.

The displacees are subjected to health hazard and its ultimate result is epidemic. The government should provide them with health care and low-cost house with sanitary latrine and arsenic-free drinking water facilities. This assistance will aid them in coping to their hazardous riverine environment.

The homestead plot, housing materials and financial support are crucial to their resettlement. They receive skimpy financial assistance from their neighbors and/or kin but not from any organizational sources. So, government and non-government organizations should allocate sufficient financial assistance with low/without interest so that they can take advantage and cope with the situation.

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A REVIEW OF RECENT LITERATURES ON THE REPRESENTATION OF ENVIRONMENTAL NEWS IN MASS MEDIA

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Abstract

This is a qualitative scrutiny in the field of social science to explore the coverage of environmental news in mass media. The study has been conducted on the basis of purposively selected online literature published between 2000 and 2017. The review is mainly focused on to explore how mass media represent the environmental news. I have been searched over 100 databases from online and it is found that approximately 50 literatures are closely related to the present study. The study found that media is the most effective tool for environmental communication. But mass media are not communicating properly with the people that mean environmental issues are not represented properly in mass media. As a result, people are not informed about environmental information. Basically representation of environmental news is determined by some factors such as occupational norms, editorial policy, media ownership, advertising pressure, political economy, sources of news etc. More studies on this area have been recommended to increase environmental news coverage in mass media.

Keywords: Literature, Environment, Mass Media, Representation, Environmental news

1. Introduction

Environment is the fundamental need for all living things. If the environment is not protected, the existence of life on the planet would ultimately be impossible. Moreover, serious environmental degradation has taken place all over the world including Bangladesh. That is why; environmental issues become very important and sensitive globally. Environmental degradation is a lack of environmental awareness. People need to have a common understanding of the role played by human beings in reducing or worsens environmental degradation. Therefore, environmental awareness building is needed to reduce environmental degradation. People need to have a common understanding of the role played by human beings in reducing or worsens environmental degradation. In this regard, media has a big role to play in making people aware of environment issues and taking actions to protect the environment. According to Tengbers (1995), "2600 global media channels operate with the support of about 3000 satellites, reaching nearly 1.5 billion people across the globe. It can be argued that the majority of global citizens learn about environmental issues beyond their immediate surroundings, through the global media".

It is said that media is the mirror of society and fourth pillar of the state. In these days media has become the important part of life. However, we know that, mass media is to inform and educate the people. Only media can motivate people easily. Media also set the agenda. The dynamics of contemporary socio-ecological systems media representations are very important. The media agenda influences and interacts with the people and the policy agenda. When all of these are connected then the state of the environment would be changed (Lyytimaki, 2012).

Media is part of social environment. It spreading information to the public and change their attitudes and behaviors. Several studies have been found that media is most effective tool to create the awareness about the environmental issues among the public. Like that, the media is an important agent and it increases awareness among the people in environmental information (Sessions, 2003). Throughout, mass media coverage has proven to be a key contributor and the coverage of environmental problems increase the awareness about

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environmental information. Media representational practices have shaped perceptions of various issues of environment, technology and risk. It also broadly affects translations between science and policy (Weingart *et al.*, 2000).

However, the effects of mass media are powerful, direct and uniform. The media influence has been regarded as a powerful force in society for many years. The Media is known as the main source of information and audience rely on mass media heavily. Media also plays role of commentator, interpreter and gatekeeper (Prasana, *et al.*, 2012; Selo *et al.*, 2015). According to Schramm (1964), mass media can perform a number of roles alone or together with other institutions.

Representation of environmental issues in mass media influences public's environmental consciousness directly and can motivate societies to take actions to control environmental hazards. However, communicating information about the environment is very challenging due to the complex nature of environmental information. Sometimes, the meanings are lost throughout the process of news construction. Thus, it is important to conduct such research which can be a pioneer study in this field. It is expected that the present study will provide a platform for the understanding of environmental issues represented in newspapers for readers and future researchers.

The main objective of this study is to give a brief concept about the representation of environmental news in the media. To achieve the major objective of the study; following specific objectives have been undertaken:

- to explore the role of media in creating environmental awareness
- to examine the practice of presenting environmental news
- to identify the factors that determine environmental news presentation

2. Materials and Methods

The study is a qualitative in nature which implementing content analysis. Content analysis is a systematic research method used here to describe the role of mass media in building environmental awareness and explore its manifest and latent levels. Content analysis method is expressed in the study to interpret the role of media for environmental awareness, practice of presenting environmental news and factors that relating environmental news presentation. Approximately fifty literatures relating to the coverage of environmental news in mass media have reviewed purposively. Consultations of documents i.e. online published journals and other documentary resources including related research reports, books, and dissertations. Collected data have been analysis qualitatively. Importance of environmental news representation related nine (9); the main part practice of presenting environmental news related thirty (30) and factors behind environmental news representation related nine (9) literatures have been reviewed.

Content analysis method was preferred as the prime method of data analysis for hermeneutics analysis of text's data in this research study. In this research, the main goal for application of qualitative content analysis was to provide knowledge and understanding the representation of environmental news in mass media. The collected material was again revised, and many influential headings were written down in a separate area to maintain the detailing of all aspects of the content. Using this method of analysis, it was possible to identify relevant themes and to provide a comprehensive understanding and to gain critical overview of overall aspect of representation of environmental news in global theoretical perspectives.

3. Results and Discussion

The present investigation was designed to study the review of the recent literature on the representation of environmental news in mass media. Keeping the above aspect in view, relevant literatures have been reviewed. Literatures have been divided into three sections for better understanding these are given below:

3.1. Importance of Environmental News Representation

Media is very effective and it persuades and informs people to think or do something (Rowland, 1979). Media coverage of environmental issues helps the readers to understand the concepts that shape their beliefs and perspectives. Previous research has shown that newspapers about environmental information for people act as a primary source (Wakefield and Elliott, 2003). Many studies have found that news media are the most effective tool about environmental communication. Like that:

Jamilah *et al.* (2015) revealed that in Malaysia mass media serve as a tool in promoting ideas related to various issues including environmental issues. Over the years, media has acquired a reputation for being able to influence the thoughts and actions on public. Kushwaha (2015) also revealed that media plays an important role in forming the positive attitudes of the public towards the environment. Kapoor (2011) found that information channels are very important and it can play an important role to bridge the gap between science and society.

According to Yadav and Rani (2011) mass media plays a vital role in educating and enlightening the people. Boykoff and Boykoff (2007) found that news media plays a key role in shaping the climate change information. Shanahan (2011) also stated that media plays very important role in educating people about climate change. Kakade *et al.* (2013) found that a large percentage of respondents agree that they get complete information regarding climate change through media. Slovic (2000) revealed mass media as an effective tool for widening public awareness about environmental issues. Aoyagi-Usui (2008) found that the Japanese get information about environment issues from television and daily newspapers.

Based on the above literature it is found that mass media are the most effective tools to create environmental awareness. Media coverage of environmental issues helps the readers to understand the concepts that shape their beliefs and perspectives. The mass media play an important role in forming the positive attitudes of the public towards environment.

3.2. Practice of Presenting Environmental News

As though mass media is very important to build up environmental awareness but these are not presented properly. A number of studies have been found that mass media does not represent environmental issues properly. Such that:

Saikia (2017) found that in India media involvement of environmental news is only event-based, environmental issues are not media's prime agenda. Moreover, environmental issues are not get fair and optimal space in India's media. Norma and Hasan (2007) found that environmental news is underrepresented in Malaysia and Newzealand. Their studies raised questions regarding the quality of news coverage because in these countries coverage of environmental news are conflict-framed, one-source event stories, with high dependency on government officials. Hoerisch (2002) mentioned that media's supply of information on environment is still quite low and one-sided, even though over the last few years the coverage on environmental issues has increased. Nitz and West (2004) found that environmental data is not represented in media properly and the data is poisoned by inconsistencies and distortions. Liebler and Bendix (1996) identified that in environmental news presentation, scientific explanations and pro-environmental "mobilizing information" is typically devoid and "crisis- or event-oriented" environmental issues has been represented by the press.

Okoro and Ninaji (2012) revealed that environmental pollution in the region by the press received low coverage. They also revealed that environmental issues are largely confined to the inside pages of the newspapers. Koser (2017) found that in Pakistan household waste management is not proper and due to the organizational agenda it got very little space in mass media. Roba (2012) found that environmental issues are not getting proper emphasis by the media and these issues were too brief and other issues get priority in coverage. Boyagoda (2017) stated that environmental issues are not only ignored but they were given very small portions in the newspapers. He found that environmental issues are not covered sufficiently and

presentation of environmental issue is marginalized. Thirumalaiah and Aram (2016) revealed that local environmental issues and voices of the common people are underrepresented in the newspapers.

Dutt *et al.*, (2013) explored that climate change and global warming got the highest priority with 75% items which constituted more than two third (77%) of the total space occupied by environmental issues. They found that environmental coverage is a sub topic and climate change and global warming got leading position. Therefore they want to indicated in there article media representation of environmental issues only event based, local environmental issues are not coming in the media. Billet (2009) also indicated that media represent only event-based environmental stories. Dutt and Garg (2000) found that environmental issues were negligible and ranked at 10th position as percentage in Indian news media.

Stamm *et al.* (2000) stated that media coverage of environmental issues was not accurate and also this coverage created misconceptions. They suggest that for solving the environmental problem the accuracy of media coverage and more research in this area are needed. Sampei and Usui (2008) revealed that newspaper coverage of global warming issues increased dramatically. They also indicated that the high level and front pages of media coverage of global warming influenced the environmental concerns of large proportion of people. So they focused only the amount of newspaper coverage. Das and Zaman (2009) concluded that environmental reporting in Bangladesh is strong and journalisms sub-field is growing. Reza (2010) also found that newspapers in Bangladesh gave a special attention on global climate change issues, impacts and debates, which were particularly relevant to Bangladesh. He indicated that the proactive nature of the newspaper of Bangladesh on environmental issues is indicativebut the press not given the proper emphasis on these issues.

Payver (2004) found that the press performance regarding the coverage of Gender Environment and Development (GED) isweak and remained neglected. The press does not reflect the actual needs of people in India. Boykoff and Roberts (2007) explored that the media has at times kept the issues of climate change alive, but it is also limited. Ahmed and Lateh (2016) concluded that environmental reporting is still predominantly presented as straight news in the mainstream media of Malaysia. Lyytimaki (2012) showed that the absolute number of the environmental stories has increased but their average share from all news content has remained relatively low. This result highlights the importance of taking media coverage that account as a key factor in the formulation and implementation of environmental policies aimed at broad-based actions.

Atieno and Njorge (2014) found that climate change continues to receive low coverage locally in Kenyans news media. Mare (2011) found that the reports on climate change in Southern African newspapers were not reflective of necessity and this reports would be dismal , negative, event-based, official centered, and buried in the inside pages. Inaugural Ranking Report (2013) focused that entertainment news get more coverage than environmental news stories. The lack of environmental news coverage is observed here. Local newspaper prioritizes environmental coverage than mainstream news organizations. Faridah (2009) found that much news was not covered on environment issues in Malaysian press in spite of the fact that it is considered important. Christos and Demetrius (2008) found that the environmental issues of global interest are ignored by the local newspapers but most of the environmental issues in the local newspapers concern events of regional significance. Kostarella *et al.* (2013) found that there is reduced reliability is needed with regard to the quality of environmental informationin the Greek media. Prasad *et al.* (2009) found that environmental stories on other topic were very few and also shorter in duration and the stories were mostly related to crisis and disaster oriented like landslides and floods.

Neverla *et al.* (2012) highlighted that due to low literacy rate providing knowledge on climate change issues is difficult in Bangladesh. It is found that government policy makers and environmental activists are extensively represented by the media, but the voices of scientists and lay people are underrepresented. Dependency on western media and limited journalistic capacity are the major impediments to climate change in Bangladesh (Tandfonline , 2017). Another study argues that in Bangladesh the nature of environmental news reporting is

mainly “episodic”. Based on the above literature it is found that environmental issues are not presented properly in mass media. Mass media do not give special attention on environmental issues although it is very important.

3.3. Factors Behind Environmental News Representation

A number of studies have been proved that media is very effective for environmental communication. But why mass media does not represent environmental issues properly? Anderson (1997) found that editorial policy and ownership, advertising pressure, news cultures and the limitations of time and space influenced environmental news. Considering this aspect some literature has been reviewed. Dispensa and Brulle (2003) found that media frames are determined by three main factors. These include advertisers, reporters and media owners. Boykoff (2009) pointed out that media representation practices are influenced by many external and internal factors. The complex factors shape these representations that how environmental news are being represented. Norma and Hasan (2007) found that in Malaysia and Newzealand most of the time newspapers are reactive towards environmental issues, because many factors are determining the quality of news coverage of the environmental issues. They found that occupational norms of journalism, media ownership, relationship between journalist and source are determining the quality of news coverage of environmental issues. Adam (2000) stated that environmental news are ignored and this items are used as filler items in the absence of something more urgent because many factors are determined to shape that news items. Calderón *et al.* (2015) found that in Spanish the politicians are principal sources of environmental news and this factor shape the environmental news. As a result, media coverage does not respond to local needs. Pompper (2004) revealed that the mainstream newspapers relied heavily on government and industrial sources. Jalarajan and Sreekumar (2011) stated that commercial interests and media autocracy imposes the escalation of commercial imperatives in media production, which directly paved to a shifting representation of environmental issues.

Francis (2014) found that the crime stories dominated all the sampled newspapers and agriculture stories were covered least. Boykoff (2010) indicated that print media coverage of climate change stories in Indian English language peaked around the time of summits in Copenhagen and Cancun. In this context environmental cyclical factor shaped the environmental news. Tong (2014) found that the Chinese newspapers reporting also framed by some factors. In a way criticizing the economic priority and policies of the Chinese government these frames are accountable for environmental problems. The above literature revealed that mass media representational practices about environmental issues are determined by some factors which shaped environmental news.

3.4. Findings

Based on literature review it is explored that media is the most effective tool for environmental communication but environmental coverage in the mass media was not sufficient. It is inaccurate, misconceptions, distortions, misconstruction, one sided, event based, official centered, buried in the inside pages etc. Such type of characteristics was shown in the practice of presenting environmental news. It also revealed that many factors are contributing to presentation of environmental news. Most of the literature, researcher have been suggested that much more coverage of environmental news is needed in mass media. It is though that the people in Bangladesh depend on the media for environmental information heavily, but the coverage of environmental news is rather limited compared to other areas although the nature of environmental reporting is strong in here. Most environmental stories are event based and episodic in here, these are not educating the people. Furthermore, a little research has been carried out into the media-environment relationship in Bangladesh.

4. Conclusions

The presentational practice in mass media is very important now a day. But review literature found that practice of presenting environmental news is quite poor in mass media. So people are not informed about environmental information by mass media. Though environmental issues are more sensitive in all over the world, but mass media are not communicating properly with the people. In the process of presenting environmental news some

internal and external factors were relating to this news, which are shaped environmental news. The contributing factors are political economy, editorial policy, media ownership, advertising pressure, news cultures, limitation of time and space etc. As media is the most effective tool for environmental news communications, further study is needed in this area for increasing environmental news representation.

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PRACTICE OF INDIGENOUS KNOWLEDGE FOR COMMUNITY RESILIENCE TO CLIMATE CHANGE IN WAZIRPUR UPAZILA, BARISAL, BANGLADESH

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Abstract

Bangladesh is one of the most vulnerable countries to climate change. Coastal belt of Bangladesh is so exposed to natural calamities. Enhancing community resilience activities are the key strategy that can combat with climate change induced hazards especially in developing countries like Bangladesh where poverty and natural hazards are ancient adversaries of development. This paper aims to explore how community practiced and initiated climate resilient technologies can meet the objectives and enhance community resilience for curbing the worst impact of natural hazards. This study was conducted based on primary data collection method through personal observation, site observation, Focus Group Discussion and face to face interview. It has revealed that traditional practice and knowledge of community level can act as a stepping stone to minimize the worst effects of disasters and enhance the resilience of the community people. To build resilience, some of their traditional practices are homestead plinth raising, compact and inland settlement, fuel preservation method like machan, rick, dried cowdung, cropping pattern, seed collection from harvest and preservation at home, protection against heat and flood in fishery, local variety in poultry farming and homestead based primary treatment. Adoption of modern technologies like Bondhuchula, Solar Household System and irrigation by water pump is also noticeable that is also increasing resiliency. The paper has concluded by recommending the policy formulation for encouraging and sustaining the community level traditional practices and knowledge should be incorporated to our national policy. Community itself can be much resilient through applying these traditional ways against calamities.

Keywords: Climate change, Community resilience, Indigenous knowledge

1. Introduction

Climate change impacts such as sea level rise, more frequent and intense storms, increased rainfall, and warmer ocean temperatures exacerbate hydro-meteorological hazards. Thus, not only coastal communities are prone to more extreme hydro-meteorological but also they are affected by rapid-onset disaster changes resulting from climate change such as coastal erosion, coastal flooding, water pollution and loss of coastal ecosystem and biodiversity, which pose a direct threat to livelihoods.

Natural disaster is a perennial problem for coastal areas of Bangladesh. Strategic geographical location, climate change, and past history of cyclones in Bangladesh have created a great demand of creating and rearing up community knowledge and practice for tackling the badly impact of these calamities (Haque and Haque, 2009). Southern part of Bangladesh is highly exposed to hydro-meteorological hazards. Therefore, southern part of Bangladesh is prone to climate related hazard and disasters such as cyclones, tropical monsoons, storms surge, tidal surge, drought, erratic behavior of extreme heat and rainfall, flash floods, sea level rise and salinity (Paul and Rashid, 2017). Climate change is no more an environmental concept it has emerged as biggest developmental challenge for Bangladesh (Faroque *et al.*, 2013).

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An important component that addresses such risks and that can increase the resilience of communities is their local and indigenous knowledge. Although recent years have marked by the decline of such local and indigenous knowledge, in combination with scientific knowledge. It helps community manage crises such as natural hazards, economic problems, or political conflict (Ellen, 2007). It is evident that indigenous knowledge and practices can improve disaster preparedness has grown since the 1970's (Dekens, 2007). Indigenous perceptions of disasters and coping mechanisms are also being documented (Bankoff, 2004, Blolong, 1996, Campbell, 2009, Lavigne et al., 2008). Globally, the Hyogo Framework for Action (2005-2015) has acknowledged "traditional and indigenous knowledge and cultural heritage" as one source of "knowledge, innovation and education to build a culture of safety and resilience at all levels" (UNISDR, 2007).

It is logical that the community will be the first line of defense in preparing and responding in the event of a natural hazard (Brennan et al., 2006). So Bangladesh is not exceptional in this respect. Local residents are the first responders to climate change. These community and villages have some vitally important assets to deal with hazard and disasters. These may include knowledge of disaster warning signs, locally safe and vulnerable areas, experiences of past disasters, methods of survival and social relations that are often vitally important in coping with crises. Involvement of these community knowledge and technology into disaster risk reduction (DRR) and climate change adaptation (CCA) can enhance community resilience which is prerequisite condition of sustainable development.

As a result, community knowledge, indigenous knowledge and practices can be mobilized and encouraged to help them adapt to climate change impacts and reduce disaster risks. The study tries to make a survey on Wazirpur communities to suggest the value of blending community knowledge & practices into scientific knowledge and strategies for coping with climate change and variability for enhancing community resilience against worst impacts of disasters.

The Wazirpur Upazila of Bangladesh is a rural area and is affected by various climatic hazards almost every year. This community also has experiences to combat with natural calamities like cyclone, flood, water logging, heavy rainfall, water shortage, nor-wester, hail storm, tidal surges etc. So they have learnt how to cope with these natural hazards. Their indigenous knowledge and practices contribute them in having resilience. Therefore, it is essential to identify and assess their vulnerability and capacity like indigenous knowledge and practices, as it is logical to understand the existing level of resilience of the community in order to enhancing community resilience. This study aims to diagnose and find out these resources to enhance the capacity of communities for building a resilient community against the climate change impacts.

The present study seeks to contribute to existing knowledge and research by presenting new rural data from one part of the country which highlights the ways in which vulnerable individuals and groups in Bangladesh seek to be resilient through existing resource and knowledge with changing climatic effects. Exploring of existing community knowledge and practices will enable community and administrative body to understand better community resilience and give scope of improvement of resilience. The study combines a synthesis of background literature with a set of specially-collected qualitative and quantitative field data.

The main objective of this study is to find out some prevailing best indigenous knowledge and community practices which enhance the resilience of community and increase coping patterns to climate change. The specific objectives of the research are: To explore climate resilient community knowledge and practices in study area. To analyze the practical efficiency of those practices in gaining community resilience to climate change. Indigenous knowledge related to climate change hazard is necessary to promote and advertise the use of such indigenous knowledge to increase the resilience of communities against natural calamities and hazard.

2. Materials and Methods

This study was conducted at different unions (i.e. Shikarpur and Bamrail) of Wazirpur Upazila under Barisal District (Figure 1). It is the second smallest upazila of the district.

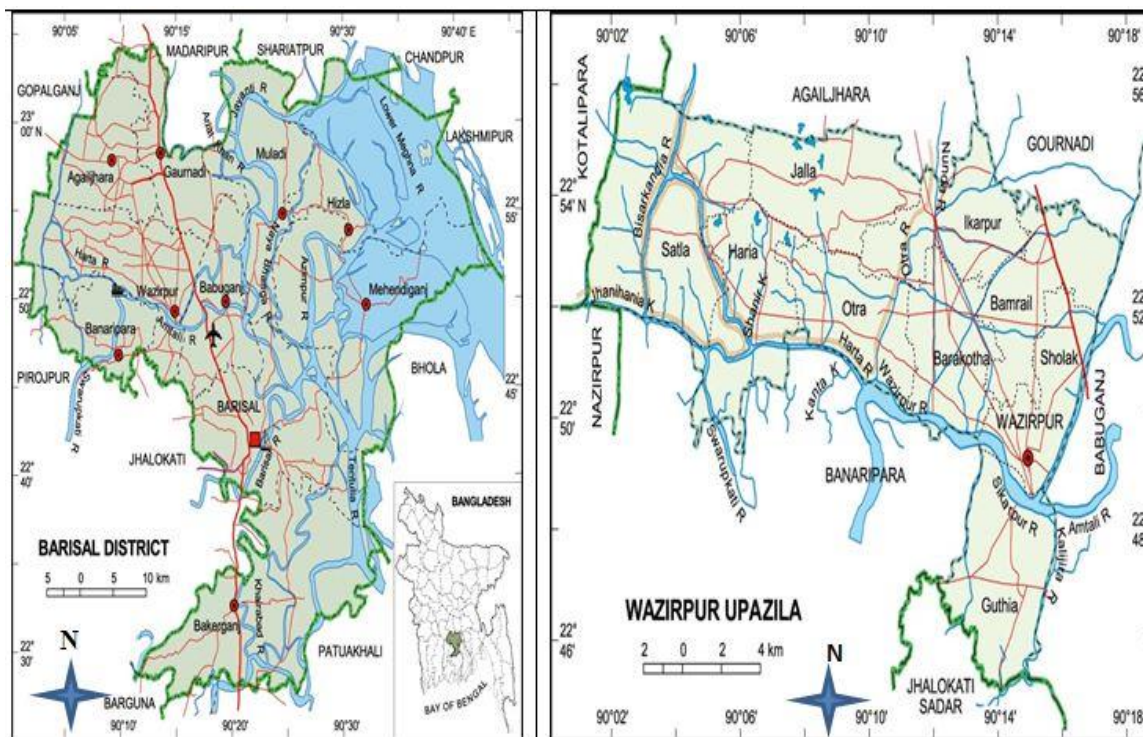


Figure 1. Map of the study area (source: <http://maps-of-bangladesh.blogspot.com>).

The Wazirpur Upazila is positioned between $22^{\circ}43'$ and $22^{\circ}56'$ north latitudes and between $90^{\circ}01'$ and $90^{\circ}18'$ east longitudes. The Upazila has an area of 248.36 sq km. with 8.8 sq km river area. The Upazila consists of 9 Unions, 118 populated Mauzas and 125 Villages. The study was conducted in Bamrail Union and Shikarpur Union. Population of the Upazila is 2,34,959; of which male 48%, and female 52%.

2.1. Data Collection

2.1.1. Profile of Study Sample

This study is based on face to face interview, questionnaire survey and Focus Group Discussion (FGD). Samples were taken from household for questionnaires survey in a random process on 100 households which were selected randomly (Figure 2). But the female participants (54%) were more than male (46%) in this study. Among all participants of questionnaire survey middle aged people (17-40 years) were more than others.

The participant involved in questionnaires survey and focus group discussions have come from various occupations. Most of the household's main income source is agriculture. They also generate income from fishery, handicraft, poultry farming, livestock rearing, business etc.

2.1.2. Data Collection Methods

Primary data were collected through interview, questions and from related documents. During the process of data collection, the investigator has collected qualitative documents, journals, articles, public documents or private documents. For primary data, interview protocol is used for asking questions and recording answers during this

qualitative and quantitative research. The study was carried out based on primary and secondary data collection to accomplish the objectives of the study. Through qualitative and quantitative research methods, this study attempted to explore the local knowledge and practice in response to different kinds of hazards on different sector such as housing, agriculture, health livestock, fishery, and poultry and so on. The participants or respondents were old men, women and community leader etc. The questions were asked based on their experiences and responses to hazards.

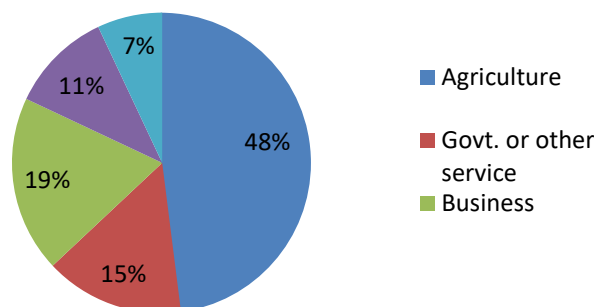


Figure 2. Percentages of participants on basis of income sources.

2.1.3. Data Analysis

The collected data and information from the community were categorized and presented in graphs. Then data is represented by different bar diagram, pie chart, column and other charts with the use of Microsoft Excel 2010.

3. Results and Discussion

3.1. Probable Climate Induced Hazard

The people of Wazirpur Upazila have to face flood, cyclone, nor-wester, storm surge, water shortage, hail storm, heavy fog, heat wave, heavy rainfall and so on. They notice the change in seasonal pattern. The period and duration of seasons is changing. It fluctuates from its normal trend. The people also experience the changing nature of climatic hazard. The frequency and intensity of hazard has got change. Figure 3 shows that the hazards of study area according to intensity and frequency. It was calculated by analyzing Focus Group Discussion (Appendix I).

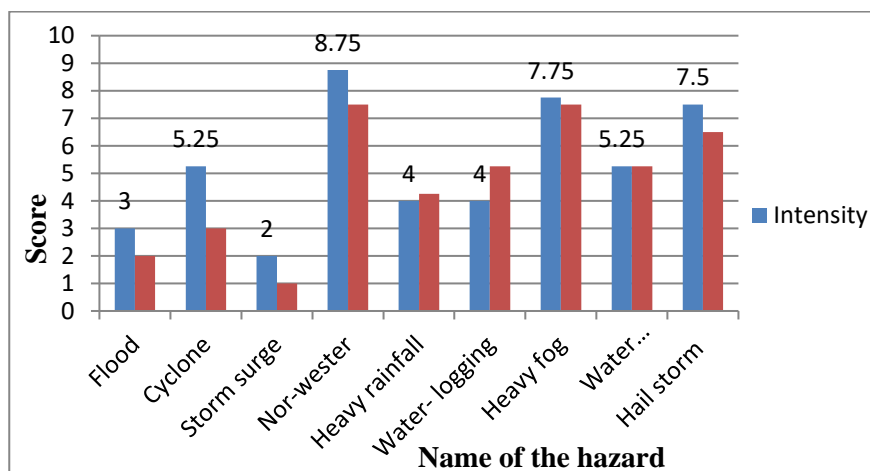


Figure 3. Hazards of Wazirpur Upazila according to intensity and frequency.

3.2. Resilience of Community

Since for a long time the people of Wazirpur Upazila have been facing various climate induced hazard. They have prepared themselves capable to fight against those hazards. They have some indigenous knowledge those make them able to fight with hazards. The people of that community are being come to the light of education and modern technology. They are adopting those scientific knowledge to increase their resilience.

3.2.1. Homestead Technology

3.2.1.1. Plinth Raising

The Wazirpur Upazila suffers from flood, water logging, storm surge and heavy rainfall. To avoid this problem they make their house in high land and raise their plinth of house higher. They raise their height of house floor almost 1.5 feet to 3 feet high from land level. Figure 4 shows that 59% household raises their household plinth more than 2 feet and 38% household raise 1-2 feet.

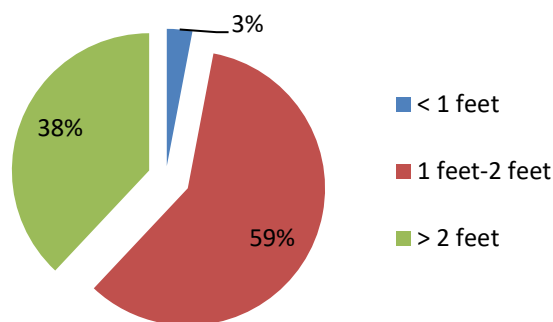


Figure 4. Plinth level of houses of Wazirpur Upazila.

3.2.1.2. Location and Pattern of Settlement

Location and pattern of settlement are the most important factors determining people's vulnerability to a tropical cyclone and storm on the Bangladesh coast (Alam and Collins, 2010). Community people of Wazirpur Upazila (WU) also frequently differentiated vulnerability to previous cyclones and storms like Nor-westers by form of settlement. Most of the past devastation occurred in single and new settlement. People of this community make their houses from their experiences in the inner land of the community. These settlements are mostly compact in nature, consisting on average of six or seven houses called *Baris* with dense tropical forest surroundings. This type of settlement is less susceptible to severe cyclone and later storm-surge.

3.2.2. Cultivation Technology

3.2.2.1. Irrigation with Water Pump

Due to climate change the cyclic pattern of season has changed. At present rainy season often comes in wrong time for cultivation. Late occurrence of rainfall or less occurrence of rainfall put farmers in difficulty. The people of Wazirpur Union also practice irrigation with water pump. Almost 54.47% of total cultivable land is irrigated by water pump (Figure 5).

3.2.2.2. Cropping Pattern Technology

To be resilient to any hazard, food and livelihood security is essential. So, to have food security and more production from land, farmers of this area try to cultivate land more than one times. They cultivate crops of Robi, Kharip-1 and Kharif-2 season and vegetables grow all the year round. Most of the farmers cultivate crops two times

in two seasons. Survey data shows that almost 41% farmers cultivate their land two times while 29% farmers cultivate only one times (Figure 6).

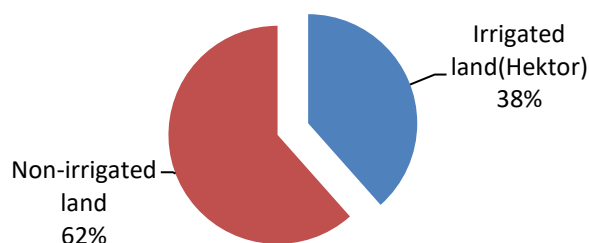


Figure 5. Percentage of irrigated land with water pump in the study area

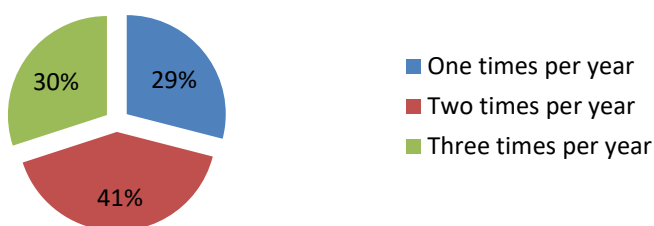


Figure 6. Cropping frequency of Wazirpur Upazila.

3.2.2.3. Seed Collection from Harvest and Preservation at Home

The people of studied community mostly use their own processed seed for crop production. They store seed from their production and use them next time cultivation. Their own preserved seed give more production and these seeds are more pure and free from adulterant. These preserved seed are also considered as savings which can be useful in time of hazard. The people make dry the seeds in sun and stored in a water tight container. In questionnaire survey it is seen that almost 67% farmers depend on seeds preserved at home. In case of some vegetables they collect sapling from local market generally.

3.2.3. Technology in Fishery

3.2.3.1. Protection against Heat

People of Wazirpur Upazila also cultivate fish in their pond. In dry period the aquatic system get dry and water level decreases. Water temperature affects growth and reproduction of fishes. Excessive temperature of water can cause death of fishes. Therefore, it is necessary to take some measure for heat protection.

Water Hyacinths: People grow water hyacinths in their aquatic system specially pond to avoid excessive sun light. Water hyacinths also keep the water clean. Water hyacinths increase the dissolved oxygen level of water. Almost 34% people grow water hyacinths in their ponds (Figure 7).

Sheds: People are found in Wazirpur Upazila to make sheds on pond. They use bamboo and coconut leaves or Hogla pata to make this sheds. This gives a place of shadow and colder space to fishes. This is very effective in hot summer for growth, metabolism and reproduction of fishes. Almost 38% people make sheds on ponds in summer season. **Tree on Bank:** In some household, people plant trees on the bank of pond. These trees prevent the sun light to reach to the water and to increase water temperature.

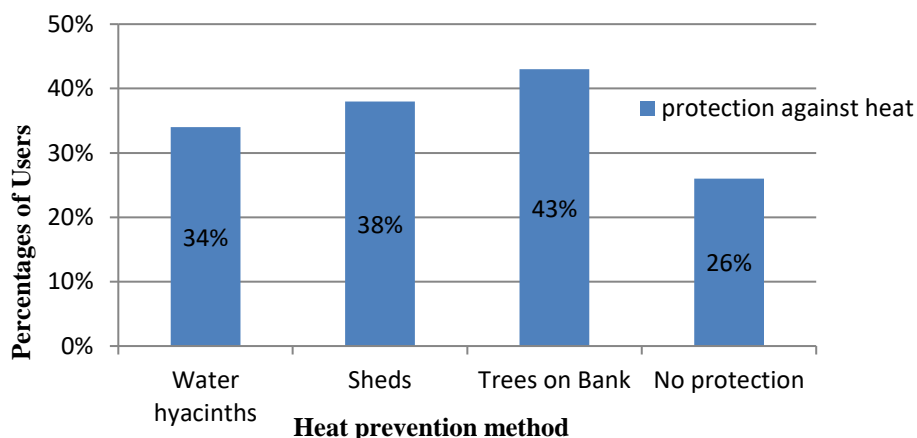


Figure 7. Heat prevention method practiced in Wazirpur Upazila.

Figure 7 reveals that almost 34% participants use water hyacinths for heat protection, 38% participants make sheds on ponds, 43% participant plant trees on bank and others have no protection.

3.2.3.2. Protection from being Flooded

During flood, storm surge or excessive rainfall, water level of aquatic system increases. Water can be flooded over pond's bank as well as the fishes can be got out from ponds with the water flow. Figure 8 shows that the percentage of practiced method to protect from being flooded.

Net: In studied area, net is used as the barricade on the bank of ponds to prevent fishes from flowing out. A long fence is made of net around the pond. Water can pass away the net but fishes are kept by net. Some people use cloth like "Shari" to make fence. Thus farmers lessen their loss.

High Bank of Clay: Also, it is seen to make the bank of ponds higher by clay from surface level. They build the bank enough high so that the water cannot be flooded easily.

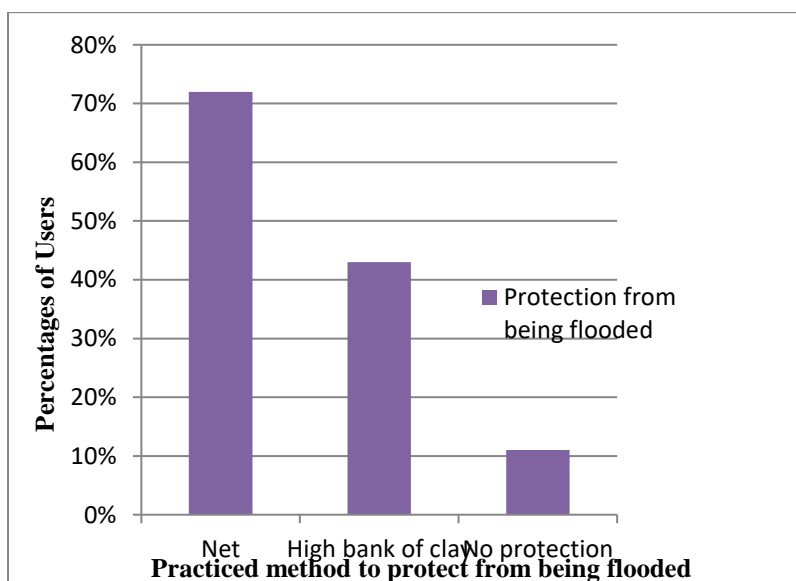


Figure 8. Measures practiced to prevent loss from being flooded in Wazirpur Upazila.

3.2.4. Protection of Poultry

Excessive cold can cause disease of poultry and cause rapid death. Community of study area raises hen, duck and pigeon. People have to loss their hen due to extreme cold.

3.2.4.1. Clay Made House

Clay is good material to protect heat and cold. People of studied area are found to make house of hen by clay. They built up that house with mud, brick and straw. These are good insulators. These keep home warm in winter and cold in summer. Only 18% household make poultry house with clay. Almost 69% households make their poultry house with wood.

3.2.4.2. Dried Wooden Chaff and Jute Sack

Dried wooden chaff can hold heat and absorb moisture. This keeps the place dry and avoids damping. Jute sack is used as cover on wooden house of hen in winter. Maximum people keep dried wooden chaff into poultry house. They dry this chaff in sun with interval of some days.

3.2.4.3. Rearing local variety of poultry

Local variety of poultry does not need much protection against cold and heat. They are genetically resilient with our weather pattern and can adapt easily to normal change of climate. This type of variety is called “Desi Murgi”. It is found that almost 77% people rear local variety of poultry (Figure 9).

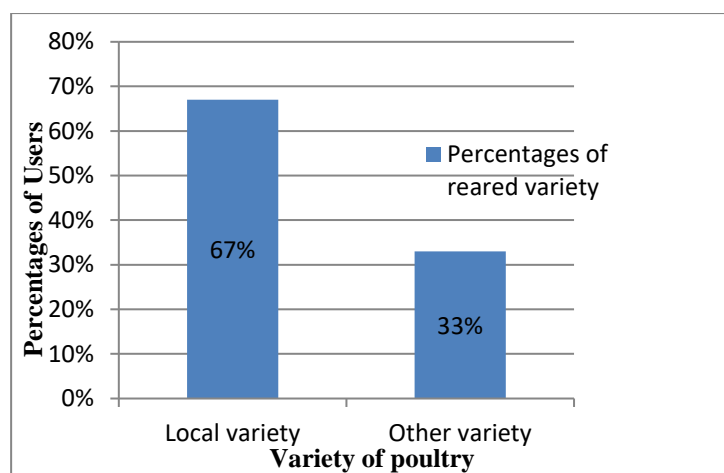


Figure 9. Percentages of local variety of poultry reared in Wazirpur Upazila.

3.2.5. Fuel Preservation Technology and Cooking System

The studied community use mainly wood, dry leave, cow dung as fuel for cooking. People store and conserve fuel using traditional preservation technology to use them in future.

3.2.5.1. Traditional Technology

Mancha System: People make a storing shelf of wood and bamboo upon their stove in kitchen. This is called “Mancha”. They put wood on that shelf. This is an optimum use of place to store wood. Moreover, Wood on Mancha get dry by the ascending heat from stove. This is effective in rainy season when drying wood by sun is difficult. This traditional technology is used by 48% people of the field survey (Figure 10).

Rick or Stack of Leave: People of the studied community use dry leave for cooking. Generally women of the household collect fallen down leaves from trees and dry them in sun. Then the dried leaves are stacked in a place.

They process this rick or stack in such a way that the leave are not become wet by rain or water. They cover the rick with coconut leave or polythine. They can use these leave when they necessary. These can be kept in homestead yard or other open place. This traditional technology is used by 43% people of the field survey (Figure 10).

Drying Cow Dung in Sun: Cow dung is a good fuel. People collect cow dung and dry them in sun. Dried cow dung can be conserved and used any time for cooking. Burning cow dung is also good for environment. This causes less pollution to air. Usage of cow dung as fuel can reduce pressure on forest for fueling wood. This traditional technology is used by 12% people of the field survey (Figure 10).

Under specific Tin shed: People of the studied area keep their fuel under Tin shed. This technology is very suitable to keep the fuel dry during rainy season. This traditional technology is used by 38% people of the field survey (Figure 5).

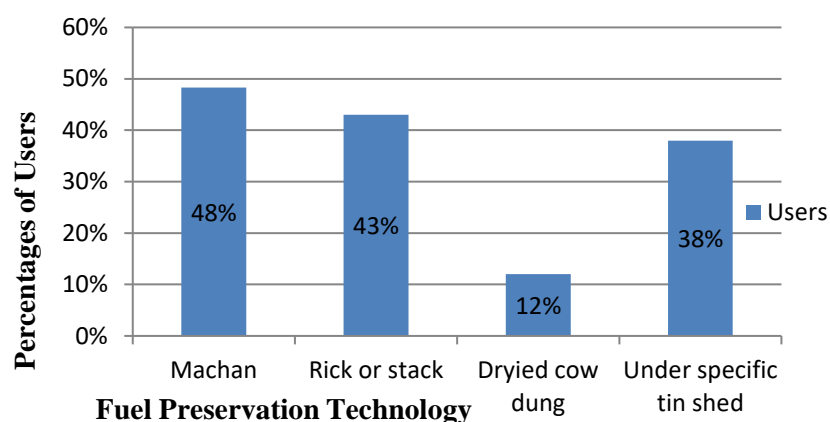


Figure 10. Fuel preservation technology of Wazirpur Upazila according to users.

3.2.5.2. Bondhuchula Technology

Bondhuchula is specific kind stove of clay used for cooking in Wazirpur Union (Figure 11). It is a modern technology adopted by people of community. This Bondhuchula conserves fuel and produces less smoke. This is environmental friendly and good for people health. The people of this community have learnt how to make this stove and know the usefulness of the Bondhuchula. This technology is used by 47% people of the field survey (Figure 11).

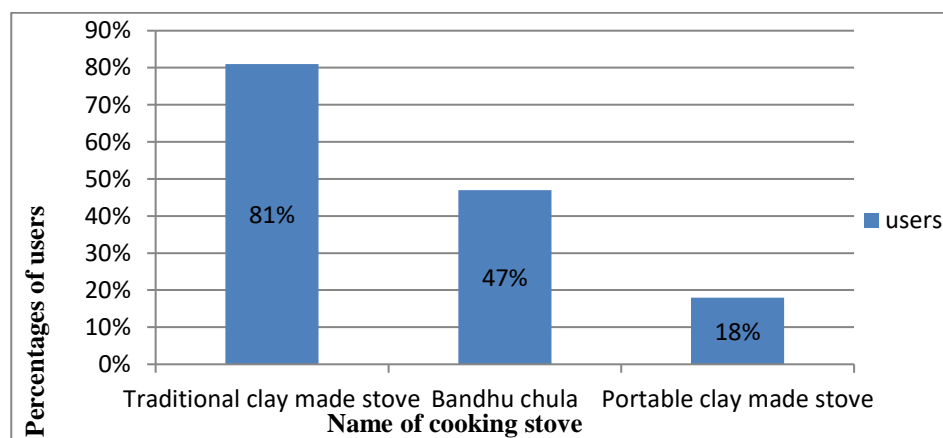


Figure 11. Users of Bondhuchula and other cooking stove.

3.2.5.3. Portable Clay Made Stove

Another type of stove is found else traditional clay made stove (Figure 11). This is portable stove made of clay. In some household, they keep portable stove beside traditional or Bandhuchula. This can be used during flood period or when kitchen is not suitable for cooking. The main advantage of this stove is portability. When flood or rain water enters into kitchen or cyclone or nor-wester destroy kitchen, this stove will be very much effective in those crisis. This technology is used by 18% people of the field survey (Figure 11). However, 81% people also use traditional clay made stove (Figure 12).

It is revealed that the people who use Bandhuchula are highly satisfied with this technology (Figure 12). Almost 41% among 47% Bandhuchula users gave opinion that this is a good and effective technology whereas others are less satisfied. They feel problem with its use of dry leave as fuel.

3.2.5.4. Renewable Energy Technology

The community has been brought under electricity facility. Almost 99% households have electricity facility. Generally, they use the Pollibiddut line for electricity. In this study, it is found that 94% households depend on Pollibiddut (Figure 13). But, the community is also familiar with solar household system.

Solar household system: Solar household system is a source of electricity. This system produces electricity from the power of sun light. A little but some household, almost 14%, have adopted solar household system (Figure 13). The solar system is used in some household as supplement to Rural Electrification Program. This technology reduces the pressure on increasing demand of electricity. The number of solar system users is increasing day by day.

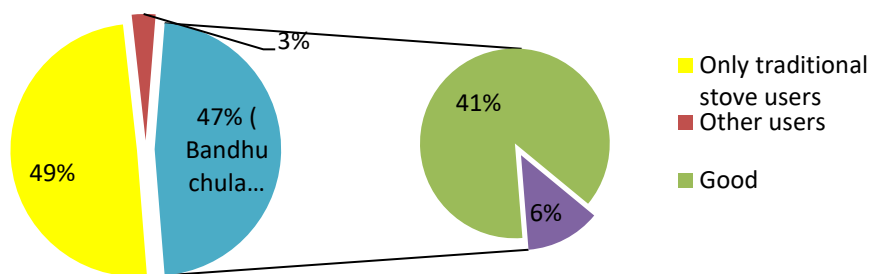


Figure 12. Level of satisfaction among Bandhuchula users

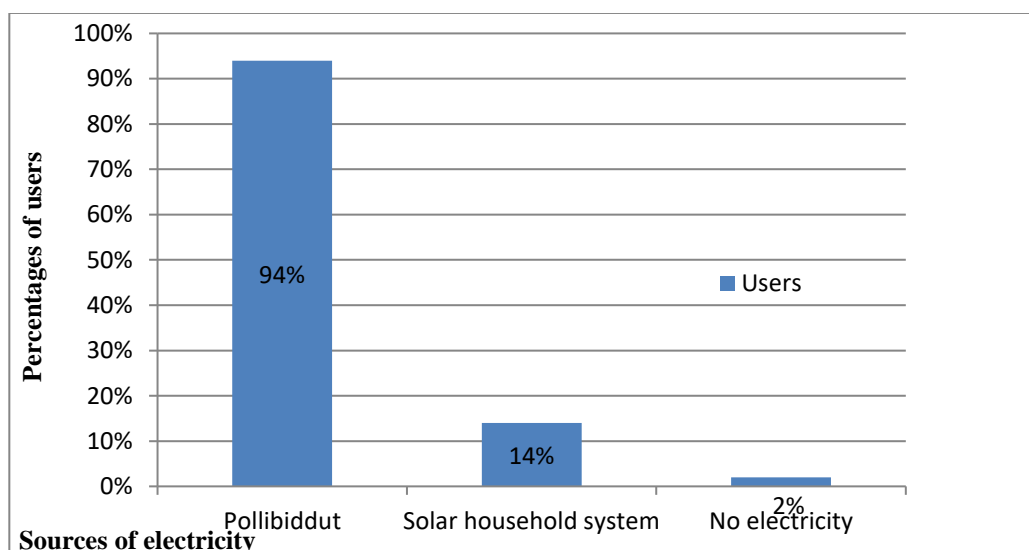


Figure 13. Source of electricity of Wazirpur Upazila.

3.2.6. Homestead Based Primary Treatment for Biological Hazard

During natural hazard, it is seen that various water born and infectious diseases break out and can create epidemic. This time homestead based primary treatment is very helpful to lessen sufferings and ultimately save life. Proper primary treatment can prevent epidemic nature of diseases. The studied community has practical knowledge of treatment in various diseases. They have been applying this knowledge from a long time ago and getting cure by this. Almost 61% people are highly satisfied (Figure 14).

Diarrhoea is a common disease seen in flood and other natural hazard. They take help of herbal treatment beside clinical treatment. They make juice from a local plant named “*Thankuni*” or “*Adathonthoni*” and feed the patients. They said there is also a plant named “*Misripanapata*” which also can cure Diarrhoea. A special type of banana called “*Bichikola*” is very much effective in Diarrhoea treatment according to the people’s concept.

Dysentery is water born disease that cause epidemic. According to their saying, local plant called “*Badaillapata*”, “*Thankuni*”, “*Moskolota*”, “*Telachora*”, “*Bichikola*” etc. are helpful for getting cure. They use the turmeric powder as an antibiotic of dysentery. People make chop with “*Kolai dal*” and turmeric powder and give to the patients. Some make pill of turmeric powder and eat with rice.

People of this area prefer primary treatment for “Chicken Pox” at home rather than going to doctor in this disease. People keep *Neem* leaf near patients of pox. *Neem* is a tree that has many remediable characteristics. *Neem* leaf prevents infection. The patients are fed bitter guard, boiled food without oil and vegetables.

Extreme cold can cause cough and fever. The studied community has the habit of usage of Basil plant (*Tulsipata*), *Basokpata* and honey in cough. If cough coagulate in lung, they have embrocation by hot mustard oil.

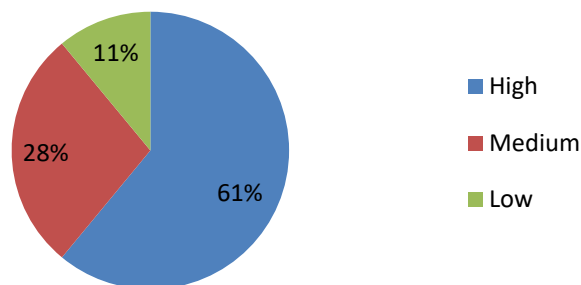


Figure 14. Satisfactory level of homestead based primary treatment.

4. Conclusion and Recommendation

Climate change is a concern and challenge for Bangladesh especially southern communities. These communities are already experiencing some of the detrimental impacts of climate change on their food and water supplies, health and overall livelihoods. Solutions need to be forthcoming. Indigenous knowledge is key to increasing the resilience of coastal communities to natural hazards and the impacts of climate change. However, it is necessary to connect by scientists, practitioners, and policy-makers. Indigenous and scientific knowledge needs to be integrated with science and technology before it can be used in policies, education, and actions related to disaster risk reduction and climate change adaptation. This study has provided a brief snapshot of some of the valuable indigenous knowledge and practices present in Wazirpur Upazilla and its surroundings environment. These community uses indigenous knowledge and practices to adapt the changing environmental conditions as a result of sea level rise, cyclones, droughts, uncertain behavior of erratic rainfall, and flooding. In this paper, we present integrated indigenous and scientific knowledge could be used to climate change adaptation plans at the community level in Bangladesh. Such knowledge and practices are a valuable and critical part of the solution to the impacts of climate change.

The study has showed that these knowledge and practices need promotion and some financial support for improvement. Concerned authority can use them as tools of their climate change risk management approach and increase community participation in sustainable development. Government and various NGOs and INGOs should apply effort to explore the community practiced technology with scientific knowledge and make them well-furnished for betterment and to enhance effectiveness.

Recent literatures and present study have showed that the value of blending traditional community indigenous knowledge & practices with scientific knowledge in strategies for coping with climate change & variability has exerted a great achievement. On the basis of the above scenario, the following policy recommendations are made to achieve success and sustainability for enhancing community resilience to Climate change through indigenous and scientific knowledge and practices in southern part of Bangladesh as follows:

- ❖ Ensuring that Disaster Risk Reduction (DRR) and climate change measures are gender responsive, sensitive to indigenous knowledge systems and respectful to human rights.
- ❖ Engaging of Civil Society Organization (CSOs), NGOs and volunteers to promote indigenous knowledge and practices along with scientific knowledge into Climate Change programs.
- ❖ Community's structural adjustment such as wetlands preservation & management, canal, pond, social forest should be preserved and maintained as per necessity to ensure fishery, poultry and food security.
- ❖ Current Community knowledge and practices for adopting climate change should be properly documented and archived as per national and local importance.
- ❖ National and Local media and press should come forward to publish and promote these knowledge as a stepping stone for minimizing disastrous effect of climate change.

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APPENDIX- I

Calculation of frequency of hazard for figure 3:

Questions used in FGD: How frequent do you Experience X hazard?

X = Flood, cyclone, nor-wester, storm surge, water shortage, hail storm, heavy fog, heat wave, heavy rainfall

Choose the frequency

Frequency	1-2 years	2-5 years	More than 5 years
Score F	10	5	1

Frequency of any specific hazard X from FGD 1= F_{x1}

So the average frequency of any specific hazard X from four FGD, $F_x = F_{x1} + F_{x2} + F_{x3} + F_{x4}$

For example average frequency for flood $F_{flood} = 1 + 5 + 1 + 5 = 3$

Calculation of intensity of hazard for figure 3

Question used in FGD: How is the intensity of any specific hazard X you experience?

X = Flood, cyclone, nor-wester, storm surge, water shortage, hail storm, heavy fog, heat wave, heavy rainfall

Choose the intensity

Intensity	Severe	Medium	Low
Score I	10	5	1

Intensity of any specific hazard X from FGD 1= I_{x1}

So the average intensity of any specific hazard X from four FGD, $I_x = I_{x1} + I_{x2} + I_{x3} + I_{x4}$

For example average intensity from four FGD for flood $I_{flood} = 1 + 5 + 1 + 1 = 2$

Table for Figure 3. Hazards of Wazirpur Upzila according to Intensity and Frequency

Hazards	Intensity 1=Low, 5=Medium, 10=High					Frequency 1=Low, 5=Medium, 10=High				
	Dokkhin Sikarpur	Ichladi	Purbo Dhamsar	Vorosa kathi	Average	Dokkhin Sikarpur	Ichladi	Purbo Dhamsar	Vorosa kathi	Average
Flood	1	5	1	5	3	1	5	1	1	2
Cyclone	1	10	5	5	5.25	1	5	1	5	3
Storm surge	5	1	1	1	2	1	1	1	1	1
Nor-wester	10	10	10	5	8.75	10	10	5	5	7.5
Heavy rainfall	1	5	5	5	4	10	5	1	1	4.25
Water logging	5	5	5	1	4	5	10	5	1	5.25
Heavy fog	5	10	10	10	8.75	5	10	10	5	7.5
Water shortage /drought	1	10	5	5	5.25	1	5	10	5	5.25
Hail-storm	5	5	10	10	7.5	1	5	5	10	6.5

Source: Focus Group Discussion

OPTIMIZATION OF ALKALINE EXTRACTION OF NATURAL DYE FROM *Acacia catechu* AND ITS DYEING ON SILK FABRICS

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Abstract

This study aimed at the potential application of '*Acacia catechu*' a natural dye as a brown colorant for natural silk. The natural dye was extracted from the raw Khair (cutch) by aqueous, alkaline, acidic, and alcoholic medium using the standard procedure. The alkaline extraction condition of the natural dye from the raw Khair was optimized. The dyeing was carried out with and without the use of mordants and the colorfastness properties of the fabrics were determined. The optimized alkaline extraction conditions for pH and temperature were found to be 12 and 90°C, respectively. The UV-VIS Spectrophotometric analysis result confirmed the presence of catechin compound in Khair dye. The results of the colorfastness properties of the dyed silk fabrics using different mordants were found to be fair to good.

Keywords: *Acacia catechu*, Absorbance, Dyeing, Mordant, Colorfastness.

1. Introduction

Natural dyes are gaining popularity due to its lower environmental impacts and simple dye processing method. Local plants are a potential source of natural dyes. Dyes derived from natural materials such as plant leaves, roots, bark, insect secretions, and minerals were the only dyes available for the coloring of textiles until the discovery of the first synthetic dye in 1856 (Druding, 1982). The advent of synthetic dyes caused a rapid decline in the use of natural dyes, which was completely replaced by the former within a century. However, environmental issues in the production and application of synthetic dyes revived consumer interest in natural dyes during the last few decades of the twentieth century. Several synthetic colorants have been banned because they cause allergy-like symptoms or are carcinogens (Ratna and Padhi 2012; Melgoza *et al.*, 2004; Kulkarni *et al.*, 2011). Due to harmful and toxic effects of the dyeing effluent, researchers have diverted their interest towards in dyeing. Natural colorants are non-carcinogenic, non-toxic and biodegradable in nature (Banchero, 2012; Adeel *et al.*, 2013; Padthy and Rathy 1990; Eom *et al.*, 2001).

Natural dyes are mostly non-substantive and usually applied to textiles with the help of mordants. Mordants are metal salts which produce an affinity between the fabric and the dye (Vankar *et al.*, 2009; Samanta and Agarwal 2009). Potash alum, ferrous sulphate, copper sulfate, stannous chloride etc. are the commonly used mordants. Color fastness is the resistance of a material to change any of its color characteristics or extent of transfer of its colorants to adjacent white materials in touch. Generally, light fastness, wash fastness, rub fastness (Dry and Wet) and perspiration fastness are considered for textile fibers.

Acacia catechu (A. *catechu*) is a medium-sized, deciduous, thorny tree which grows up to 15 meters tall. It is a native of Central and East Africa, Southern Asia, Bhutan, Thailand, China, India, Myanmar, Nepal and Pakistan (Vankar, 2002). *Acacia catechu* grows in abundance in the northern part of Bangladesh, especially in Rajshahi district. Main chemical constituents of *Acacia catechu* from the heartwood are catechin and epicatechin (Lakshmi *et al.*, 2011). The powdered heartwood of A. *catechu* contains tannin phyto-constituents. Catechin is a type of natural phenol and an antioxidant. It is a secondary metabolite of the plant that belongs to the chemical family of flavonoids. It is used for dyeing of fabrics with different mordants. It yields brown,

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reddish brown and black shade. The color obtained exhibit very good fastness properties (Vankar, 2002). The present study focused on the development of the optimum extraction conditions of coloring component from the natural material *Acacia catechu* (Khair) and its application on silk fabric with chemical mordants. The study also analyzed the light, wash, rubbing and perspiration fastness to check the colors stability.

2. Materials and Methods

Raw Khair (cutch) chips were collected from the local market and then washed with tap water and sun dried. The dried chips were ground to make them powder. A detailed extraction method was followed to extract the dye from the acacia powder. Finally, the extracted dye was applied to the silk fabrics following the necessary steps of scouring, mordanting and dyeing and is discussed below.

2.1. Dye Extraction

The natural dye was extracted from raw Khair by aqueous, alkaline, acidic, and alcoholic medium using standard procedure (Samanta and Agarwal, 2009). In the aqueous technique, 10g of raw Khair powder was added to 100 ml of distilled water and boiled at 90° for 120 min. In the acidic technique, 10g of raw Khair powder was added to 100 ml 1% of HCl solution and boiled at 90° for 120 min. In the alkaline technique, 10g of raw Khair powder was added to 100 ml 20 g/L NaOH solution and boiled at 90°C for 120 min. In the alcoholic technique, 10g of raw Khair powder was added to ethanol in water at a volume ratio 1:3(v/v) and boiled at 90 °C for 120 min. The hot dye extract was filtered through the fine cotton fabric and allowed to cool. Finally, it was filtrated once again through Whatman 40 filter paper. The extracted dye solution was dried in an oven at 60–70°C to get the powder formed. The absorption spectra of the dye extracts were measured using a UV-Vis spectrophotometer.

2.2. Scouring of Silk

Silk fabrics were washed in a solution containing 0.5 g/L Na₂CO₃ and 2 g/L non-ionic detergent solution at 50 °C for 25 min, keeping the Material to Liquor ratio (M:L) at 1: 40. The scoured material was thoroughly washed with tap water and dried at room temperature. Then it was soaked in distilled water for 15 min prior to dyeing or mordanting.

2.3. Mordanting

Four different laboratory grade mordants were used, i.e., potassium aluminum sulphate (AlK(SO₄)₂.12H₂O), copper sulphate (CuSO₄.5H₂O), ferrous sulphate (FeSO₄.7H₂O) and stannous chloride (SnCl₂.2H₂O). The samples were subjected to pre-mordanting (before dyeing) with 5% potash alum and 3% with other mordants on the weight of fiber (o.w.f). The temperature of the dye bath was raised to 80°C over a period of half an hour and left at that temperature for another 30 minutes (Monali *et al.*, 2016). The mordanted fabric was immediately used for dyeing because some mordant are light sensitive (Jothi, 2008; Kulkarni *et al.*, 2011).

2.4. Dyeing

The extracted liquor was used to dye silk fabrics in a previously prepared dye bath of *Acacia catechu*. The initial temperature of the dye bath was 40 °C which was slowly raised up to 90 °C. The dyeing process was carried out for 60 minutes keeping the material to liquor (M: L) ratio of 1:50 with stirring occasionally (Deshmukh and Dongre 2015). The material was left in the dye bath overnight to complete the dyeing process. In the next day, the dyed fabrics were taken out from the dye bath and washed well under running tap water and dried under shade.

2.5. UV-Visible Spectral Analysis

UV absorption spectra of the extracted dyes were recorded at wavelength of 200 to 800 nm on a UVmini-1240, Shimadzu, Spectrophotometer.

2.6. Color Fastness Test

The colorfastness of the dyed fabrics was assessed by light, wash, perspiration and rub fastness. Light fastness was analyzed by exposing the dyed material to direct sunlight for 24 hours. The color fastness to light was evaluated by comparison of color change of the exposed portion to the unexposed original material (Samanta and Agarwal 2009). The wash fastness was tested by washing the dyed fabrics with non ionic soap water (2 gm/lit). The color fastness to perspiration of dyed silk fabrics were measured using ISO-105-F 10: 1998 analyzer and the dry and wet rub fastness of the dyed silk samples were tested using a crock-meter based on ISO-105-X12-2001 by mounting the fabric on a panel and giving ten strokes for dry and wet rub fastness tests. The samples were assessed for staining on adjacent white fabrics.

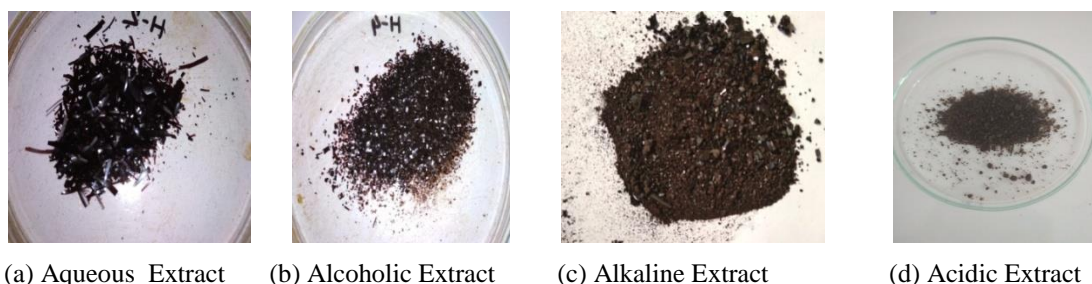


Figure 1 (a-d). Photograph of extracted Khair dye from four different medium.

3. Results and Discussion

The Khair dye was extracted in aqueous, alkaline, acidic, and alcoholic medium and the powder form of the extracted dyes are shown in Figure 1. The aqueous extraction of colorants was carried out under various conditions such as temperature, extraction time, pH, raw material concentration and Material to Liquor ratio (M: L). Thus, the optimum extraction condition was determined for a particular dye by determining the maximum absorbance or optical density value at a particular (maximum) wavelength for the aqueous extracted solution using a UV-Visible absorbance spectrophotometer.

3.1. UV Spectroscopy Analysis

The UV spectrum of the alkaline extracted Khair (Cutch) showed the presence of two major absorption maxima (λ_{\max}) in the UV region 278 and 366 nm (Figure 2). In the visible region, the λ_{\max} was found to be 761nm. The flavonoids contained unique UV active chromophore that is phenyl ring which makes it easily detectable. It has mainly two UV absorbance peak, one is range between 240-285nm and another range between 300-400nm (Dias 2011). Catechin produced a clear peak at a wavelength of 278.4 nm (i.e. λ_{\max}), in another report showed the absorption peak at 277 nm in the ultraviolet (Bhardwaj *et al.*, 2017, Rayar *et al.*, 2016). Khair dye belonging to the flavonoids group and main coloring compound was Catechin.

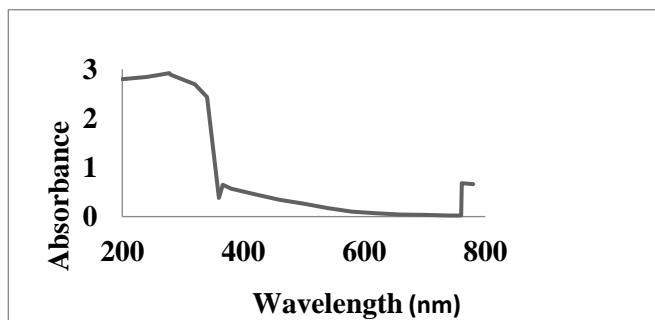


Figure 2. UV-Visible Spectrum of *Acacia catechu* dye.

The catechin forms minute colorless crystals in pure form. However, the catechins are very unstable and become oxidized by exposing to the atmosphere and become gradually colored. The catechin is acted on alkalies, causing them to absorb oxygen, giving a yellow, then red and finally a black color (Vankar, 2002).

3.2. Selection of pH of the Extracted Dye

The effective extraction depends on the medium and several other parameters. The efforts have been taken to identify a suitable solvent for extraction in the present study. The dye extract was prepared in alcohol, aqueous, acidic and alkaline media. The aqueous extract was preferred over the other extract. But the color obtained in aqueous medium was not appreciable. The alkali extracts furnished better concentration of dye solution than aqueous medium. Therefore, alkaline extract has been selected as the extraction medium.

Table 1 shows that maximum dye yield was found to be 19.4% at pH 12 (alkaline media) and the minimum dye yield was observed to be 8.6% at pH 3.4 (acidic media). The optimized pH for cutch (Khair dye) was 12 and the yield was 19.4%. Pargai *et al.*, 2016 observed the ultraviolet protection properties of nettle fabric dyed with natural dyes cutch where alkaline pH was selected for the dye extraction.

Table 1. The percentage of yield of the extracted dyes in different medium

Dyes extraction media	Weight of raw Khair (gm)	Weight of extracted dye (gm)	Percentage of yield	pH of the media
Acidic	10	0.86	8.6	3
Alcoholic		0.94	9.4	6
Aqueous		1.3	13	6.5
Alkaline		1.94	19.4	12

3.3. Optimization of Extraction Conditions

Among the four medium of extraction (Table 1), the alkaline extract prepared from raw Khair was used for the optimization study. The results of the experimental parameters and their conditions are shown in Table 2. The result shows that the optimum time for dye extraction was found to be 120 min at 90°C and the dye yield and M: L ratios were 19.4% and 1: 10, respectively.

Table 2. Parameters of the extraction of *Acacia catechu* and their optimization

Parameters for optimization for dyeing with <i>Acacia catechu</i>	Experimental settings	Optimum
Mass to liquor ratio (w/v)	1:10, 1:15, 1:20, 1:30	1:10
Dye extraction time (hr)	1, 1.5, 2, 2.5, 3	2
Dye extraction temperature (°C)	60, 70, 80, 90	90

3.4. Application of Dye on Silk Fabric

Different shades were found on silk using four different mordants and pre-mordanting techniques. Different shades obtained ranged from reddish brown to dark brown (Figure 3). In general, the dark and lightest shades were obtained through ferrous sulphate and alum, respectively. With ferrous sulfate, the color was darker, this may be associated with a change of ferrous to ferric sulfate by reacting with oxygen in the air. Ferrous and ferric forms were co-existed on the fibers and their spectra overlapped, resulting in a shift of λ_{\max} and consequent color change to a darker shade (Hwang *et al.*, 2008). Alum being alkaline in nature removes the colors and yield lighter shade.

3.5. Color Fastness of Silk

The color fastness was determined by the end use of the fabrics. It is clear that the type of mordants has influence on the fastness to light, wash, perspiration and rubbing by forming an additional linkage with dye molecules compared to the silk samples dyed without any mordant. However, fastness grades of the mordanted silk samples recorded proficient than that of the unmordanted silk samples (Table 3).

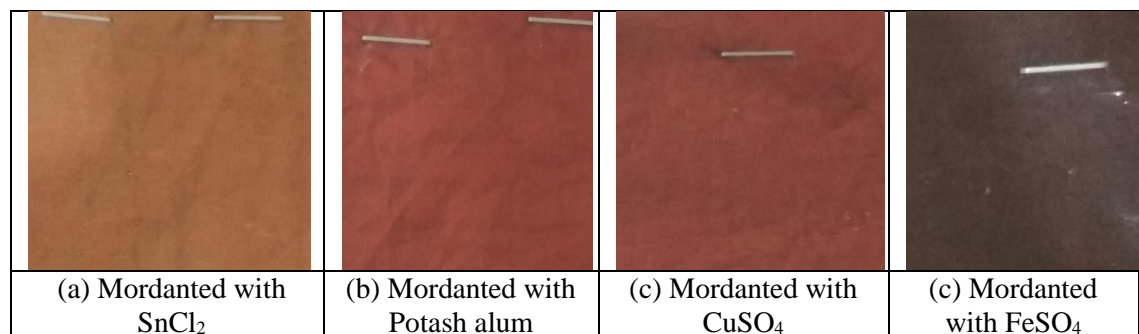


Figure 3 (a-d). Application of Khair dye on silk fabric using different mordants.

Fading of color on the textile occurs on exposure to light. Poor light fastness of some of the natural dyes can be attributed to the propensity of the dye chromophore to the photochemical oxidation. The chromophore in some classes can be protected from photochemical oxidation by forming a complex with transition metals, whereby a six member ring is formed. The photons sorbed by the chromophoric group dissipate their energy by resonating within the ring and hence dye is protected (Prabhu *et al.*, 2012). Sunlight fastness property of unmordanted and premordanted fabric sample was studied. Very good (4-5) to good (4) result was obtained for all dyed fabrics.

Washing fastness properties of dyed silk fabric showed that the color was found to be very good in the case of mordanted with SnCl_2 . However, it was found moderate in the case of unmordanted fabrics. The color fastness test results indicated that the natural dye *Acacia catechu* has the potential to be used in the textile industry. Wash fastness of the dye was influenced by the rate of diffusion of the dye and state of dye inside the fiber (Jothi, 2008). *A. catechu* contains 40-55% of tannin (Pargai *et al.*, 2016). The probable reason attributed was the tannin component of the dye, which may be helpful in bonding with the fiber, thereby assisting in the proper fixation on the fibrous material. Finally, mordanting alter the light sorption characteristics of tannin as well as make them insoluble in water and ultimately improves washing fastness properties (Swamy *et al.*, 2014).

Acid and alkali perspiration fastness properties of unmordanted and mordanted dyed fabric were poor to good. While for unmordanted, the dyed fabric found was very poor to good. For alkaline perspiration the result obtained was fair to good. Rub fastness was carried out by rubbing the fiber and checking of the shades. The results obtained for dry rubbing fastness was good to excellent for all dyed silk fabrics. While for wet rubbing fastness it was good to all samples except the unmordanted one.

The mordants enhanced the color quality of the fabrics due to the increased efficiency in absorption, color strength, color coordinates and fastness grades in terms of washing, light and rubbing and perspiration, respectively.

Table 3. Fastness properties of silk fabrics dyed with *Acacia catechu* extracts

Dyed Fabrics		Light fastness	Washing fastness	Perspiration fastness		Rubbing fastness	
				Acid (pH 5.5)	Alkali (pH 8.5)	Dry	Wet
Unmordanted		4	3	1-2	2-3	3	2-3
Mordanted with	FeSO ₄	4-5	4-5	2-3	3	4-5	4
	CuSO ₄	4-5	4-5	2	2-3	4-5	4
	Potash Alum	4	4-5	4	2-3	4-5	4
	SnCl ₂	3-4	3-4	2	3-4	4-5	4

Term for fastness properties: 5= Very good, 4=Good, 3=Fair/ Moderate, 2=Poor, 1= Very Poor

4. Conclusions

The maximum dye extraction obtained in alkaline media (19.4%) at an optimum dye extraction time, temperature and pH was 120 min, 90°C and 12, respectively. The UV spectrum of the Khair (Cutch) dye showed the presence of two major absorption peaks in the UV region 278 and 366 nm confirmed the presence of catechin and flavonoids. The study results illustrated that the extracted dye was successfully attached to silk yarn with the combination of chemical mordants. The color fastness test results indicated that the natural dye *Acacia catechu* has the potential to be used in the textile industry. The further studies would be conducted using the Khair dye with different bio-mordants and mordanting techniques and applied to different fabrics. Thus, the extraction and application of the extracted natural dye would contribute significantly in attaining an eco-friendly environment.

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DEGRADATION OF RIVER WATER QUALITY AND ITS EFFECTS ON LIVELIHOOD IN NARSINGDI INDUSTRIAL AREA, BANGLADESH

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Abstract

Industrial waste disposal into river, a common scenario in Bangladesh is affecting the water quality including the livelihood as well as biodiversity. Literature review reveals that Haridooa River in Narsingdi district is such an endangered water body which has almost lost its navigability due to industrial dumping; but very few studies have been done on it. Hence, present study aims to determine the level of pollution of this river water and its impact on the livelihood of surrounding people. In this study, a part of Haridooa River encompassing Gazaria Union, Palash Upazila, Narsingdi district has been selected as the study area and six water samples have been collected from six different sites. In the meantime, questionnaire survey was conducted on 109 households along with ten Key Informant Interviews (KIIs) and two Focus Group Discussions (FGDs). Study found that river water color is almost black with a foul odor. The basic and chemical properties i.e. temperature, pH, EC, Chlorine, Nitrogen and Phosphorous, none maintain the standard level of ECR'97; and reached in average at 35.9°C, 8.59, 1.07 µs, 0.16 mg/L, 0.05 mg/L and 5.4 mg/L respectively. The study also reflects that around 40% household head changed their occupation during ten years and among them 14.67% changed their occupation from agricultural sectors. The deteriorating water quality also increases the number of patient of some specific diseases, such as high blood pressure, asthma, skin disease, diarrhoea and malaria; and the rate of increase is 22.93%, 21.09%, 14.68% and 12.77% respectively.

Keywords: Industrial development, Water pollution, Water temperature, Livelihood, Crop production.

1. Introduction

While water is one of the most important resources for all living matters (Manjare *et al.*, 2010; Kataria *et al.*, 2011), the quality of water is deteriorating day by day (Sohel *et al.*, 2003; Alam *et al.*, 2007; Subrata, 2014). Both physical and human phenomenon are responsible for this severe condition, however, human intervention plays foremost role for degrading the quality of river water (Liyanage and Yamada, 2017). One of such human interference is urbanization which transforms agricultural land into build-up land for industrial, commercial and residential purposes; and generates waste (Redman and Jones, 2004; Dewan *et al.*, 2012) due to the lack of proper management. Amongst this different land uses, industries produce enormous harmful waste that enhance the water pollution and the pollution level is extreme and alarming in developing countries compared to developed countries (Ahmed and Reazuddin, 2000; Khan *et al.*, 2008; Liyanage and Yamada, 2017). Both surface and underground water body become affected by industrial pollutants; and river water is one of the main victims (Amin, 2015) as the industries are predominantly established alongside the river (Silva *et al.*, 2006). The discharged waste water influences greatly the standard level of dissolved oxygen (DO), biochemical oxygen demand (BOD), total coliform (TC), pH, electrical conductivity (EC) of river water (Karn and Harada, 2001; Alam *et al.*, 2007; DoE, 2015). Though the industrial growth has fostered the economic development (Szirmai, 2012), it adversely affects the environment (air, water, soil) as well as human health (Islam *et al.*, 2015a). A research by WHO presents that more than 80 percent of world's diseases are triggered by poor sanitation and contaminated water (Budhathoki, 2010).

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Since last two decades, Bangladesh is experiencing industrial growth (World Bank, 2007; BBS, 2015) and the total number of manufacturing industry is 42,792 (BBS, 2013). The spatial distribution of industry shows that Dhaka and Chittagong division have highest concentration of industries (BBS, 2015). Narsingdi, a district of Dhaka Division, which is situated at north-east of Dhaka, constitutes about 11,720 large and small-scale manufacturing industries and offers employment opportunity to more than seventy thousand persons (BBS, 2013). However, the huge number of industries generates solid and chemical wastes instantaneously and discharging those to the nearest environment including river. As a result of this, the water quality is degrading and simultaneously declining the navigability of the old Brahmaputra and Haridooa Rivers, the major rivers of this district (Bangladesh Today, 2011; Bangladesh Today, 2012; Financial Express, 2014; Daily Sun, 2014; The Independent, 2017). Thus, this severe degradation and extreme pollution are responsible for the extinction of many indigenous fishes of these rivers (Daily Sun, 2014). Additionally, such type of pollution greatly affects the life and livelihood of the inhabitants who live beside the polluted rivers. Thus, industrial pollution has become an area of growing environmental concern and Narsingdi is a part of it. Still now, so many studies have been made on river water quality issue and their impact, but almost all researches concentrated on some specific rivers (Dewan *et al.*, 2012; DoE, 2014), for instances; Buriganga, Balu, Turag river of Dhaka city as they are highly polluted by industrial pollution (Karn and Harada, 2001; Islam and Azam, 2015), and other studies give emphasize on the major rivers Padma, Meghna, Surma but hardly very few study had been conducted on the Haridooa River of Narsingdi, though this river is highly vulnerable to industrial pollution. Therefore, the study has been conducted on Haridooa River located in Gazaria Union of Palash Upazila in Narshingdi district (Figure 1). The study mainly attempts to identify the water pollution level through physical and chemical analysis of collected river water sample as well as to assess the impacts of water pollution on the livelihood of surrounding people beside Haridooa River in Gazaria Union.

2. Materials and Methods

This study is divided into two parts- firstly, understanding the level of water pollution of Haridooa River and secondly, assessment of impacts of water pollution on the livelihood of inhabitants beside the Haridooa River in the study area. Both primary and secondary data have been used in this study. Primary data has been collected in two stages during post-monsoon period (October 2016) with the help of two groups of surveyors. One group of surveyors collected 6 water samples from Haridooa River and another group of surveyors conducted 109 interviews through the questionnaire survey. Although the study has mainly been based on primary data, secondary data has also been used to supplement the primary data especially for the review of literature.

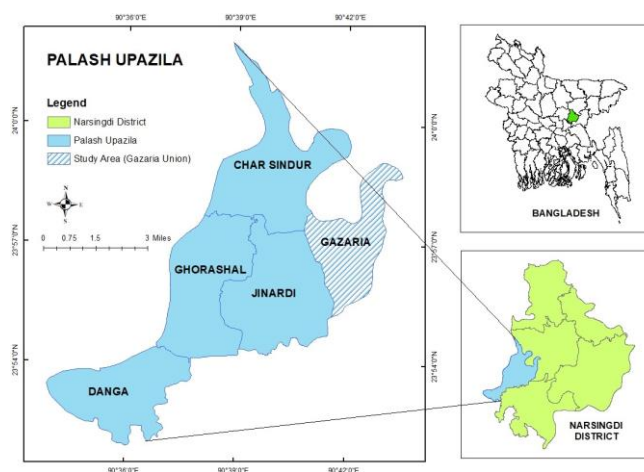


Figure 1. Map showing the study area.

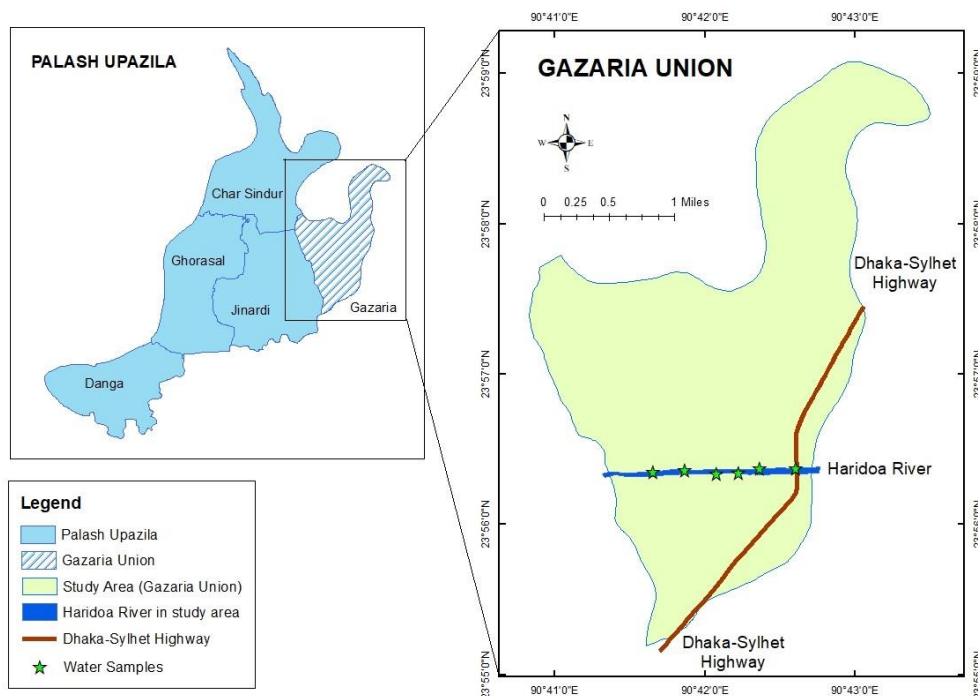


Figure 2. Map showing the points of water samples from the Haridooa River.

2.1. Measurement of Level of Water Pollution

For measuring the level of water pollution, river water samples were collected from the part of Haridooa River (about 2.30 km) which is encompassing Gazaria Union of Palash Upazila in Narsingdi District. To cover whole part of the Haridooa River in the study area, six water samples were collected from six different points maintaining an interval of more or less 0.35 km of river during October, 2016 (Figure 2) and samples were analyzed for 8 different physical and chemical parameters of river water that were Color, Odor, Temperature, pH, Electrical Conductivity (EC), Chlorine, Nitrogen and Phosphorus. Each parameter was measured five times and the mean value of the readings is presented in this paper. Some of the parameters like pH, temperature and color were measured on site and some measurements (Chlorine, Nitrogen and Phosphorus) were taken at the Department of Soil, Water and Environment lab of University of Dhaka, Bangladesh. The 250 ml plastic bottles were used for collecting water samples which were washed well with distilled water and the water samples were collected securely and sealed with proper labelling. Aeration during sampling was avoided as far as possible. The water samples were carefully transported to the laboratory and were preserved for further physical and chemical analysis. Different instruments and techniques were used for measuring the parameters of river water samples. River water color and odor were determined by observation technique, temperature by thermometer, pH by digital pH meter, EC by digital EC meter and Chlorine, Nitrogen and Phosphorus by spectrophotometer. After completion of the laboratory tests of river water samples, all readings (site reading and lab reading) of the 8 parameters have been compared to the standard values as stated by Environmental Conservation Rules (ECR) 1997, Bangladesh for understanding the water quality.

2.2. Assessment of Impacts of Water Pollution on Livelihood

In this part, questionnaire survey has been conducted on the surrounding people, who are living in the alongside of Haridooa River for exploring the impacts of water pollution on their livelihood. A structured questionnaire has been prepared, pre-tested and corrected which comprises open and close ended questions. Then 109 respondents were selected randomly from 5,693 households of Gazaria Union in Palash Upazila, who were mainly household heads of their family (BBS, 2013). In addition, 10 Key Informants Interviews (KIIs) have

been taken from local people (3 doctors, 4 school teachers, 2 Union Parishad members and 1 Engineer) and 2 Focus Group Discussions (FGD) have been conducted (combined with male and female) for understanding the impact of water pollution on livelihood of local people.

3. Results and Discussion

3.1. Level of Water Pollution in the Haridooa River

The estimated general water quality parameters and tested results are listed with compared to ECR standard (Table 1) and described the parameters one by one in below:

Table 1. Water quality variables from 6 samples in Haridooa River

Sample points	Water Color	Odor	Temperature (°C)	p ^H	EC (μs)	Chlorine (mg/L)	Nitrogen (mg/L)	Phosphorus (mg/L)
1	Black	Bitter	36.7	6.9	0.42	0.37	0.05	1.0
2	Moderate Black	Bitter	35.0	8.9	0.54	0.01	0.04	1.0
3	Reddish Brown	Bitter	34.5	9.6	0.81	0.11	0.04	1.5
4	Red	Bitter	37.2	9.6	3.12	0.25	0.05	4.0
5	Black	Unpleasant	37.2	8.6	0.71	0.11	0.10	8.7
6	Black	Unpleasant	37.2	7.9	0.87	0.12	0.02	16.2
Mean	-	-	36.3	8.59	1.07	0.16	0.05	5.4
ECR'97	Colorless	Pleasant	20-30	6.5-8.5	500	0.20	1	0

3.1.1. Water Color and Odor

Water samples collected from the sample points were more or less black in color and had foul odor that indicate highly polluted aquatic environment due to the contamination by industrial effluents. However, ECR'97 standard demands colorless and pleasant odor of water (Table 1).

3.1.2. Water Temperature

In case of surface water temperature, the ECR' 97 standard for potable water and sustaining aquatic life is 20°C to 30°C both in dry and wet season. The temperature of all water samples from six locations were within the range between 34.5°C and 37.2°C with an average value of 36.3 °C which exceeded the standard limit (Figure 3). High temperature negatively affects water quality by enhancing the growth of micro-organisms which may increase taste, odor, color and corrosion problems (UNICEF, 2008). Temperature also affects biological, chemical and physical activities in the water. Apart from this, high water temperature decreases solubility of gases such as O₂, CO₂, N₂ and CH₄ (Yilmaz and Koc, 2014). Industries located in the study area directly discharge the hot effluents into the river in the form of 'sludge' without the processing of ETP, which is responsible for discontinuing natural flow of river water. Therefore, aquatic life of Haridooa River is being destroying day by day due to the deterioration of its water quality.

3.1.3. pH

The p^H maintained by a well-buffered river can be attributed to the fact that normally running water is influenced by the nature of the deposits over which the water flows. The ECR'97 recommends a p^H value of 6.5 or higher for drinking water and p^H values between 6.5 and 8.5 for good water quality. The p^H values of Haridooa River were within the range from 6.9 to 9.6 and average value was 8.59 for the 6 sample points (Figure 4) which exceeded ECR'97 standard level. However, water with a pH value of above 8.0 is disadvantageous for the treatment and disinfection of drinking water with chlorine (UNICEF, 2008).

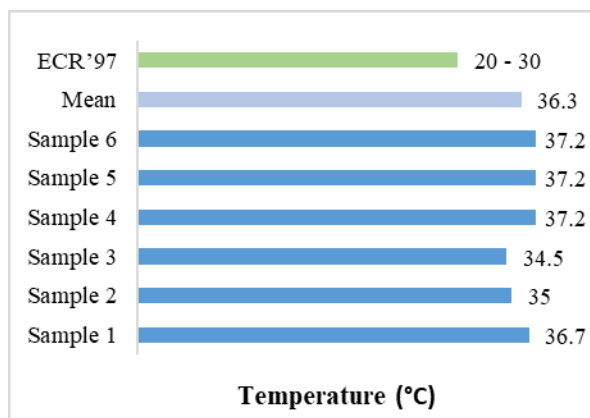


Figure 3. Analysis of Temperature.

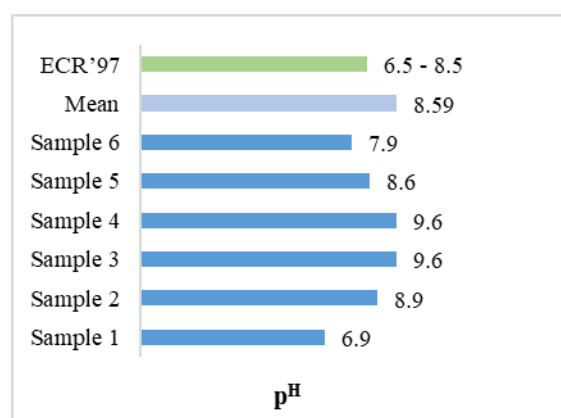


Figure 4. Analysis of pH.

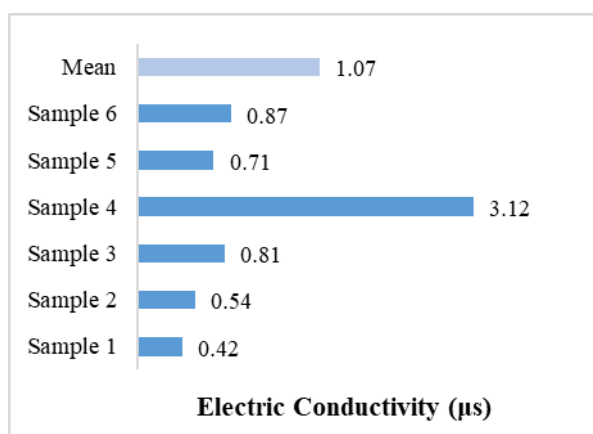


Figure 5. Analysis of Electrical Conductivity.

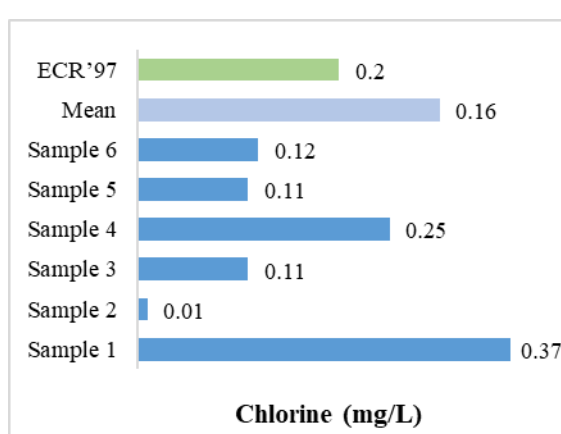


Figure 6. Analysis of Chlorine.

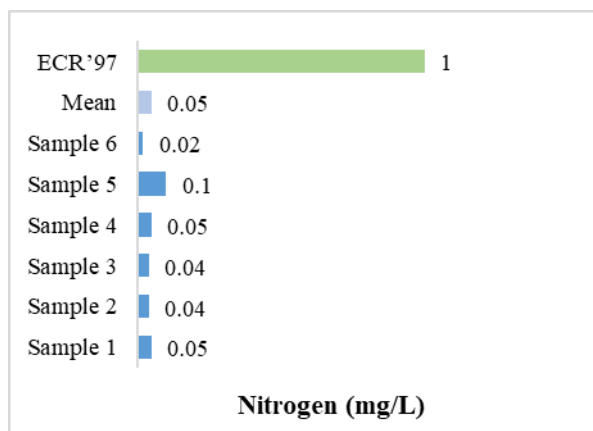


Figure 7. Analysis of Nitrogen.

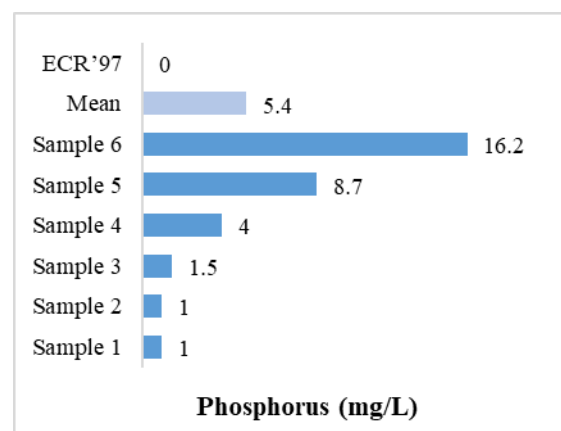


Figure 8. Analysis of Chlorine.

3.1.4. Electric Conductivity

Electric conductivity is a measure of the dissolved ionic component in water and electrical characteristic. It gives an indication of the amount of total dissolved substitution in water (Yilmaz and Koc, 2014). The ECR'97 permissible value for EC is 500 $\mu\text{s cm}^{-1}$. Among the 6 samples, tested values of 5 samples were below 1 and value of the one sample was 3.12 which indicate the very poor water quality of Haridoda River (Figure 5).

3.1.5. Chlorine

Chlorine is a pollutant in potable water. Usually safe amount of chlorine is used in the water to kill the bacteria and viruses of water that helps to keep us safe from different water borne diseases. However, high amount of chlorine reacts with dissolved organic materials in water and forms secondary chemicals which are 100 times more toxic than chlorine (Wiant, 2010). In Bangladesh, standard level of chlorine in water is 0.2 mg/L (ECR, 1997). Within these samples, two water samples had 0.37 mg/L and 0.25 mg/L of chlorine, while the rests have lower amounts of chlorine than standard. Thus, it can be stated that the collected river water was contaminated.

3.1.6. Nitrogen

Nitrogen is present in the water as well as in the environment which is a potential source of nitrate. The manure, domestic sewage, industrial wastewater, precipitation, or geological formations also contains soluble nitrogen compounds (Bojana and Mitja, 2010). In water, especially in groundwater, this is responsible for decaying of plant or animal material. Increased levels of nitrogen in the water combined with phosphorus can cause excessive plant and algal growth that depletes oxygen levels, possibly to lethal levels. Result of samples test shows average nitrogen level is 0.05 mg/L where standard value is 1 mg/L (Figure 7).

3.1.7. Phosphorus

The bulk of phosphorus in the water is a consequence of human activities such as erosion, ablation of fertilizer, and the effusion of industrial and municipal wastewater (Bojana and Mitja, 2010). Phosphorus in the water occurs predominantly in the form of phosphates, condensed phosphates and organic phosphates. An increased flow of phosphorus in the water causes increased primary production of algae and their decomposition as secondary pollution. Therefore, the determination of phosphorus in the water is important in order to evaluate the potential biological productivities of surface water. Figure 8 shows the average value of phosphorus is 5.4 mg/L where the ECR'97 standard is 0 mg/L. Sample test reveals the presence of heavy concentration of phosphorus due to industrial effluents into the river.

3.2. Water Pollution and Its Effects on Livelihood

Generally human settlement developed alongside the river for their daily necessity and river- human is closely related with each other. Similarly, different types of industries established near the river for water availability and accessibility. But, the effluents generate from the industries contaminate the river water gradually which greatly affects the human life and livelihood in adverse ways.

3.2.1. Industries and their Distance from River and Locality

Being an industrial area, various types of industries along with human settlements are located beside the river of Haridola. Nearly 50% industries are textile industries and rests of them are loom, jute, dyeing, glass and other industries (Table 2). Most of these industries are also located near the locality. While questioning the respondents, they said river water could had been used for bathing, cleaning and fishing before ten years, but rapid industrial growth has choked the river recently. The survey reveals that most of the industries are located within 200 meter of the locality and near to the river. About 44% respondents' house were located between 0 and 200 meter of the industry while 28.44% house were between 201 and 600 meter from the industries (Table 2). Therefore, industrial waste water with harmful toxic chemicals are polluting the river water as well as influencing the livelihood of local people.

3.3.2. Effects on Occupation

Incessant growth of industries increases the employment opportunity or the local people on the one hand and water pollution due to industrial discharge acts as a force to change the occupation of the study area on the

other hand. Both water and land are being polluted while industrial waste water destroys the fish habitat and reduces the fertility of cropland. These kinds of changes diminish the peoples' interest to work in agricultural or fishing sector. The study found about 40% household head have changed their profession within ten years. According to them, diversified huge numbers of industries directly influence their occupational choice and pollution and lessening fertility of agricultural land divert people from agricultural activity. The study reveals that about 15% respondents left agricultural activity in last 10 years and get involved in different industry-based activities or other tertiary activities. Since last ten years, about 11% respondents have become engaged in industrial sector as workers (Table 3).

Table 2. Types and distance of nearest industry from respondent's house.

Types of nearest industry from the river and respondent's house		Distance of nearest industry from respondent's House	
Types	%	Distance (m)	%
Loom industry	9.17	0-200	44.04
Jute mill	9.17	201-400	10.09
Dyeing industry	9.17	401-600	18.35
Glass industry	6.42	601-800	0.00
Textile industry	49.56	801-1000	5.50
Plastic industry	4.59	1000 & Above	22.02
Others industry	11.92	Total	100.00
Total	100.00		

Table 3. Occupational change due to industrial expansion induced water pollution.

Occupation	Occupation before 10 Years		Present occupation in 2016		% of occupational change
	Frequency	Percentage	Frequency	Percentage	
Agriculture	29	26.60	13	11.93	14.67
Industries worker	13	11.93	25	22.94	11.01
Govt. job	11	10.09	6	5.50	4.59
Private job	2	1.84	6	5.50	3.66
Housewife	8	7.34	7	6.42	1.58
Business	28	25.69	32	29.36	3.67
Others	18	16.51	20	18.35	0.35
Total	109	100.00	109	100.00	39.53

3.3.3. Effects on Human Health

Water is indispensable for drinking, cleaning, bathing, irrigation and fishing. Most importantly, there is an intimate relationship between water pollution and human health and that is why any harmful change in water can cause the increase of fatal diseases in human body. Most of the respondents have mentioned about the pollution of river water which has increased since last 10 years and people are in risk of several diseases like skin problem, diarrhea, malaria, asthma and high blood pressure. Figure 9 shows that 24.76% people were suffering from high blood pressure 10 years from now which increases to 47.69% in 2016. Similarly, the proportion of asthma, skin disease, diarrhea and malaria patients has increased 21.09%, 14.68% and 12.77% respectively.

3.3.4. Effects on Drinking Water Supply and Other Daily Activities

Industrial effluents have severely degraded the quality of water in Haridoda river and people can't use the water for any purpose. Therefore, tube well water is the major source for drinking, bathing, cooking, cleaning and others domestic uses. At presently, all people depends on tube well for drinking water and about 85% people use tube well water for bathing and washing. Even, about half of the people bath their cattle in tube well water (Table 4). However, ten years ago, most of the people of Gazaria Union used river water for their all daily household activities, while some people also used river water as potable water.

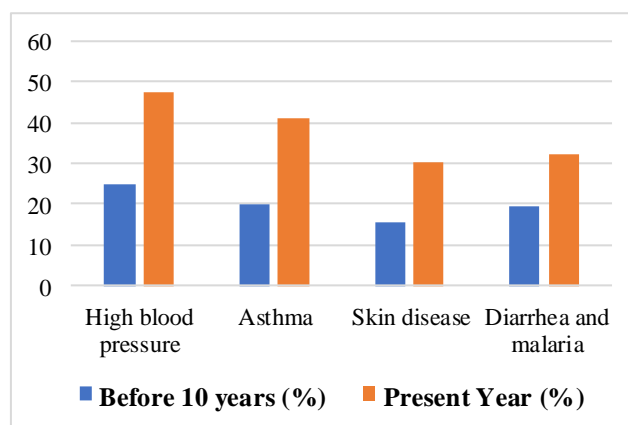


Figure 9. Effects of industrial effluents on human health.

Table 4. Effects on drinking water sources and other household activities

Sources of Water	Drinking (%)	Human bathing and washing (%)	Cattle bathing (%)
Tube well	100	85.32	45.87
Pond	0	9.17	47.70
River	0	0.92	3.67
Canal	0	0.92	1.84
Ditch	0	3.67	0.92
Total	100	100.00	100.00

3.3.5. Effects on Crop Production

Respondents of the study area stated that continuous growth of industries has amplified the local development in the cost of hazardous water and land pollution which affects the crop production rate. Along with industrial discharge, artificial drains which are often built to transfer industrial waste directly to river degrade soil quality. Besides, the use of river water for irrigation reduces soil fertility. This is why, about 56.88% respondents said about better crop production before ten years. Only 9.10% people respond they get expected amount of crops from their agricultural field. This situation is also applicable for all kinds of agricultural products (like fruits, wood and vegetables) produced in the study area.

4. Conclusion

The present study determines that the water quality of Haridoda river may not be in the position to support the aquatic life as well as domestic purpose. Due to the lack of time and resources, the sampling frame was limited to one month duration, October, 2016. The water samples were analyzed that includes Color, Odor, Temperature, p^H , EC, Chlorine, Nitrogen and Phosphorus. The concentration of p^H , Chlorine and Phosphorus were found much higher in Haridoda than the standard permissible limit, whereas EC and Nitrogen were found

lower than standard value. The presence of such imbalance elements in river water enhances the pollution level of the river and causes unmanageable problem on the livelihood of the local people. This study shows the existing status of river water which will assist to focus on other industries and river management issue to develop a water and environment friendly industrial development. It will encourage industry owner in using the water treatment plant as well as their proper management in order to ensure the quality of river water, fertility of the agricultural land, sustainable crop production, occupational stability as well as sustainable economic development. Therefore, further research studies are essential to determine the level of water pollution, the impact that industry is having on the environment and the people who interact with it.

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TEMPORAL URBAN VEGETATION MAPPING IN RANGPUR SADAR UPAZILA, BANGLADESH USING LANDSAT IMAGERIES

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Abstract

Rapid expansion of the urban area is one of the major obstacles for the consistent development of the cities in Bangladesh. Increasing population, unplanned urbanization process and conversion of bare forest land to human settlement creates significant adverse impacts on the sustainable environment and ecosystem. A sustainable urban design always requires a proper management plan. In this paper, a set of multi-date Landsat imageries of 1972, 1989 and 2014 was used to assess vegetation change mapping of Rangpur Sadar Upazila. This 42 years Landsat data reveals that about 1297 hectare vegetation areas changed from 1972-1989 year period, 5984 hectares from 1989-2014 year period and 7281 hectares from 1972-2014 year period. Moreover, a significant area of vegetation has been reduced from 1972-2014 declining from 39% of the total area to 17%. A regression analysis between the urban population and extracted vegetation area shows a robust relationship at R^2 0.94, which means that the population has a direct influence to decrease vegetation in the city. The overall vegetation classification accuracy was 95%. Due to rapid increasing of urban population, significant portion of vegetation cover areas, bare lands and small water bodies have been converted into urban built-up in the study area. It is highly recommended to prepare concrete land use policy and keep certain areas for reserve forest. It is also necessary to identify and restore local water bodies and low lands. Local city planners should follow and implement the national urban land use and agriculture plan properly.

Keywords: Vegetation mapping, Change detection, Bangladesh, GIS and Remote Sensing.

1. Introduction

Urbanization becomes an inevitable consequence due to rapid population increase (Mehta, 2000). Ecological elements along with socio-economic issues influence and affect the urban environment (Ramdani, 2013). The highly dense urban area has been growing up by eliminating urban vegetation. The alteration process becomes more crucial to realize its dwellers trend and satisfaction of having an urban green environment (Ramdani, 2013). Increasing population leads conversion of urban vegetation to human settlement and creates significant adverse impacts on the sustainable environment and ecosystem. The main factor behind the rural-urban migration in Bangladesh is poverty driven (Farhana *et al.*, 2012). Rangpur city is one of the most emerging urbanized cities in Bangladesh. According to Hassan *et al.* (2015) the annual urban growth rate of Rangpur Sadar is 20%, while agriculture growth rate is 3% during the period of 1989 to 2014. After 1990s, Rangpur District has experienced rapid urban growth, which is still an ongoing process reported in many studies. The urban transition of the Rangpur city affects the local vegetation cover and ecosystem. Therefore, vegetation cover mapping is a pressing issue to be quantified and managed local natural sources.

Vegetation mapping represents the realistic illustration of existing vegetation cover and its previous condition. The mapping technique is now-a-days broadly used as a valuable tool of understanding natural environment from its man-made creations (Yichun *et al.*, 2008). The significance of identifying vegetation cover is enormous, especially to identify the vegetation protection area and thereby the restoration process (Das *et al.*, 2013; Egbert *et al.*, 2002). To keep a balanced ecosystem of a city, it is very urgent and essential to quantify

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vegetation cover in a regular basis. The advent of technology eases the vegetation monitoring, classification and mapping technique by introducing Remote Sensing (RS) and Geographic Information System (GIS) (Maynard *et al.*, 2007; Ingram *et al.*, 2005; Lu *et al.*, 2004). The technology can provide data acquisition from several decades back to present. In change detection and mapping land cover, a number of research works have been carried out world-wide with remote sensing and GIS technologies. Leo (2005) conducted his doctoral research work on riparian vegetation mapping of several catchments in Australia using remote sensing and terrain analysis. He developed a new approach of a spatial distribution of riparian vegetation along the catchment area. Kim (2010) examined visitor-induced impacts on vegetation change and prepared vegetation mapping by using remote sensing on Cadillac Mountain, Acadia National Park, USA. He used datasets from 1979 to 2007 to identify vegetation pattern, its impact and recovery. Zhang *et al.* (2011) classified coastal wetland vegetation classes using Landsat 5 Thematic Mapper (TM) images. Andreas (2002) analyzed woody vegetation cover and created vegetation mapping of Serowe area, Botswana. He used Landsat TM, IKONOS and ASTER satellite data in 2001 for the analysis and made a comparison between those satellite sensors. Jelaska *et al.* (2005) created a vegetation map of Zumberak- Samoborsko Gorje Nature Park, Croatia using GIS tools. They used Landsat ETM+ satellite images of 2000. They identified 17 vegetation classes in that land cover and found 77.3% forest are being degraded in the park area. Iyob *et al.* (2005) examined vegetation changes in Eritrea from 1984 to 2002 using Landsat TM and ETM+ images. They categorized three vegetation classes: forest, desert and highland shrubs. Das *et al.* (2013) prepared a vegetation map of Western Ghat region of Maharashtra, India. They used Landsat TM satellite images of 2009. In their results, they found 61% moist deciduous forests, 2.10% evergreen forest, 4.91 % semi-evergreen and 4.57% dry deciduous forest. Thus, remote sensing and satellite images become the most essential and proven tools to identify and to map vegetation coverage either in small or large complex areas. The main purpose of the present study is to identify and quantify of the local vegetation of the study area during the last 42 years.

2. Location of the Study Area

The Rangpur Sadar Upazila was selected as a study area, which is under Rangpur District; located in the northwestern part of Bangladesh (Figure 1). The entire District is about 2370.45 km² in which Rangpur Sadar Upazila consists of 330.33 km² area. Rangpur Sadar Upazila is situated in between 25°36' N to 25°50' N latitudes and 89°5' E to 89°20' E longitudes. This Upazila is bounded by Gangachara Upazila at north, Mithapukur Upazila at the south, Pirgachha Upazila at east and Taraganj Upazila at the west side. The population of Rangpur District is approximately 28,81,086; in which Rangpur Sadar Upazila contains about 25,1699 (BBS, 2011). The Teesta and the Ghaghat rivers are the main hydrological systems in the study area. Geologically, the area lies under north-northwestern part of Bengal Basin and falls on old Himalayan piedmont plain (Khan, 1991). The District intensively represents recent floodplain deposits consisting soil types of silt, clay, fine to medium-grained sands (Islam *et al.*, 2014). The average maximum temperature of summer period is 32°C and average minimum temperature of winter period is 11°C. The annual average rainfall is 2931mm (BWDB, 2010).

3. Data Collection

Three multi-date geo-coded Landsat imageries of 1972, 1989 and 2014 were used to measure and mapping urban vegetation of Rangpur Sadar Upazila (Table 1). Mainly the Blue, Green, Red and Near-Infrared bands from the each set of imagery were selected to generate the Normalized Vegetation Index (NDVI) for the three dates. These geo-coded cloud free imageries which rectified to the UTM project system were collected from the United States Geological Survey (USGS) website as free of cost. To mask out the study area from the whole scene of Landsat, a vector polygon shape file was used. This shape was managed from the Bangladesh Local Government and Engineering Department (LGED). In addition to this data, temporal population of each union data was collected from the national census of the city in order to establish a regression model between the population data and declined vegetation data.

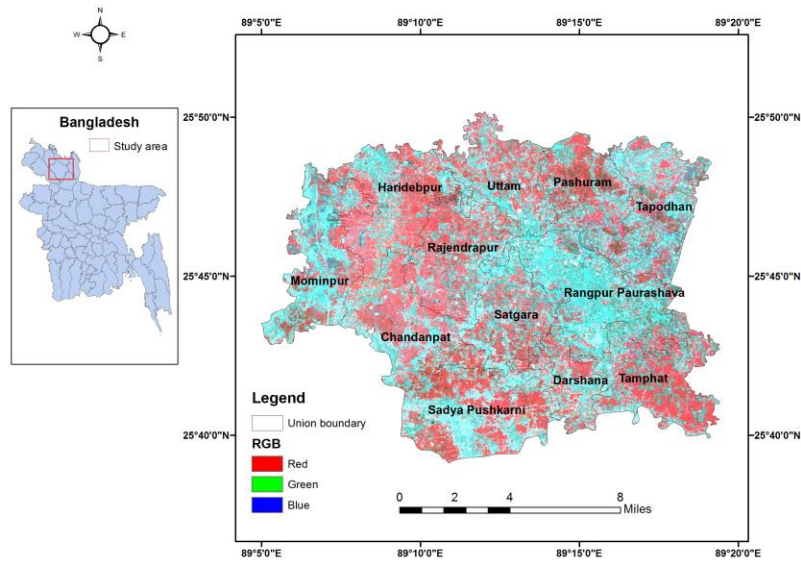


Figure 1. Location map of the study area.

Table 1. Characteristics of the Landsat data used in the study

Sensor	Remote Sensing Data				Projection	Resolution
	Row/Path	Bands	Accusation Date			
MSS	138/043	Blue, Green, Red, NIR, NDVI	2013-011-2	UTM	30.00	
TM	138/043	Blue, Green, Red, NIR, NDVI	1989-11-15	UTM	30.00	
OLI_TIRS		Blue, Green, Red, NIR, NDVI	2014-00-00	UTM	30.00	

4. Methodology

The methodology adopted to carry out the study for this paper is in Figure 2. The major steps involved during the methodology stage were image pre-processing, generation of NDVI, perform change detection analysis, area measurement, statistical analysis as well as accuracy assessment.

4.1. Pre-processing of Landsat Data

The image pre-processing comprises certain necessary preparatory steps such as radiometric correction, geometric correction and image enhancement in order to improve the quality of original images, which then results in the assignment of each pixel of the scene to one of the vegetation groups defined in a vegetation classification system (Das *et al.*, 2013). Most of the pre-processing tasks: image loading, added in layers, generation of RGB, image enhancement, radiometric correction, NDVI generation, area measurement and accuracy assessment were completed using ENVI v 4.7 and ArcGIS 10 software.

4.2. Normalized Difference Vegetation Index (NDVI)

NDVI is a slope based vegetation index widely used for extracting vegetation information from the earth using remotely sensed imageries. It is the most commonly used Vegetation Index (VI) as it retains the ability to minimize topographic effects while producing a linear measurement scale (Silleos *et al.*, 2016). This algorithm mainly uses visible RED and Near-Infrared to indicate abundance of vigor green vegetation and biomass. On the other hand, it explores the existence of soil, rock, water and ice. The classic calculation of an NDVI is shown in equation (1). From this calculation, NDVI values close to 1 represent green vegetation while near to zero or minus show non-vegetation feature.

Many remote sensing researchers used NDVI for identifying and quantifying different vegetation features. Kumagai *et al.* (2008) used Landsat ETM⁺ data to generate NDVI to analyze seasonal fluctuation as well as spatial distribution of vegetation in Kansai District, the Western part of Japan. He integrated autocorrelation with NDVI to extract vegetation changes in the city in terms of seasonal variation. A significant variation in vegetation areas was found in his paper. Nichole *et al.* (2005) identified vegetation cover and vegetation density using NDVI in Kowloon city, Hong Kong. While vegetation density and vegetation coverage are important parameters for a city in terms of urban environmental quality, the city green vegetation has been reduced at a remarkable rate in their results measured.

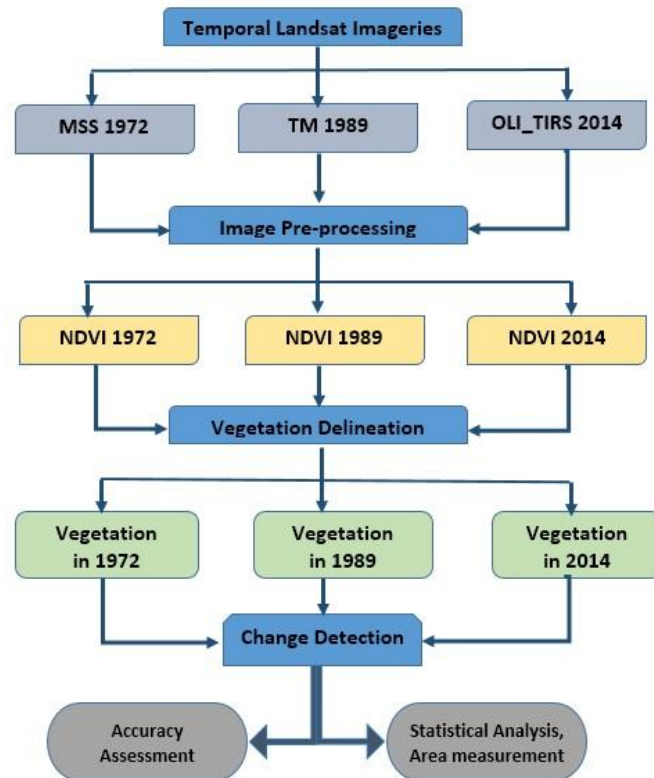


Figure 2. Methodology chart of the study.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} \quad (1)$$

For a rapidly growing city like Dhaka in Bangladesh, it is crucial to understand its vegetation pattern in order to sustain or manage urban ecology. Jaber *et al.* (2014) used temporal Landsat imageries with ten years interval to understand changes of vegetation coverage in the Dhaka city. They generated some temporal NDVI maps considering dense and sparse vegetation coverage to detect changes. From their results, a significant number of vegetation areas has been altered due to urbanization process. About 66.87 km² areas have been lost between 1989 to 2009.

Due to a broader advantage, remote sensing is routinely used tool to assess vegetation cover. Turner *et al.* (2013) used NDVI using a linear regression to evaluate vegetation in Adelaide and Mount Lofty Ranges in the period of 2000-2010. From this ten years trend analysis, they found that a million of hectares of land has been changed. Growing rapid urbanization is a great concern for city development as well as management, which is very important for the third world developing countries because it leads many adverse impacts on urban

ecology and life. Shirazi (2012) used two multi-date Landsat imageries of 2001 and 2009 in order to analyze temporal vegetation coverage using NDVI in Lahore, Pakistan. His results shown that a small amount of vegetation has been reduced over the 9 years. Moreover, he performed a correlation analysis between the urban population and extracted NDVI image data. That result shows a robust relationship between the density of population and vegetation in the study area.

Normalized Difference Vegetation Index (NDVI) is used to quantify temporal urban green space dynamics (Asmala *et al.*, 2014). They studied landuse changes in Klang-Langat metropolitan region, Malaysia focusing on urban sprawl and green space. Using NDVI maps from 1989 to 2001, they identified that NDVI value decreases by 22.25%.

4.3. Change Detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989; Nori *et al.*, 2008). In this paper post classification, comparison method of change detection used to calculate spatial changes of the urban vegetation. After each NDVI classification, subtractions from 1972-1989, 1989-2014 and 1972-2014 were performed to calculate changes of vegetation area.

4.4. Accuracy Assessment

A thematic map derived with a classification may be considered accurate if it provides an unbiased representation of the land cover of the region it portrays (Foody, 2002). Ensuring the overall accuracy of a classified image is an important task for estimating area. To be in line with this statement, an accuracy assessment was run using a set of training data and classified NDVI images. For extracting training data, more than 7000 pixels were selected for the 1972, 1989 and 2014 imageries. Those pixels were collected using GPS, Google Map and other published maps. To carry out the accuracy assessment, the following equations (2), (3), and (4) were used:

$$\text{Error matrix, } n = \sum_{i=1}^K \sum_{j=1}^k n_{ij} \quad (2)$$

$$\text{Overall Accuracy} = \frac{\sum_{i=1}^k n_{ii}}{n} \quad (3)$$

Where, n_{ii} is diagonal elements in error matrix; n is total number of samples in error matrix.

$$\text{Kappa coefficient, } K = \frac{n \sum_{i=1}^k n_{ii} - \sum_{i=1}^k n_{i+} n_{+i}}{N^2 - \sum_{i=1}^k n_{i+} n_{+i}} \quad (4)$$

Where, i is number of rows, columns in error matrix; N is the total number of observations in error matrix; n_{ij} is major diagonal element for class i ; n_{i+} is the total number of observations in row i (right margin); n_{+j} is the total number of observations in column j (bottom margin).

5. Results and Discussion

5.1. Vegetation Mapping Using NDVI

From the three NDVI images created from this analysis, about 1297 hectare areas of vegetation have been diminished from 1972-1989; 5984 hectares from 1989-2014 and 7281 hectares from 1972-2014. Within 42 years, more than 50% of the total lands from 1972-2014 has been altered into different urban land use patterns in the study area. Table 2 shows, the total vegetation areas between 1972 and 2014. Among 12 unions, substantial vegetation areas were lost in Chandanpat, Darshana, Haridebpur, Pashuram and Rajendrapur unions.

It is noted that all of these areas are being utilized as urbanization purposes at present. These three classified images and their spatial distribution of vegetation areas are in Figures 3, 4 and 5.

Table 2. Total vegetation coverage during 1972, 1989 and 2014 in Rangpur Sadar Upazila

Union	Year-1972	Year-1989	Year-2014
Chandanpat	1383	1002	454
Darshana	595	570	262
Haridebpur	1724	1076	454
Mominpur	877	982	601
Pashuram	1180	831	385
Rajendrapur	1237	1524	312
Sadya Pushkarni	1815	1352	600
Satgara	861	1219	384
Tamphat	681	716	464
Tapodhan	696	922	648
Uttam	1043	1021	405
Rangpur Paurashava	1050	632	894

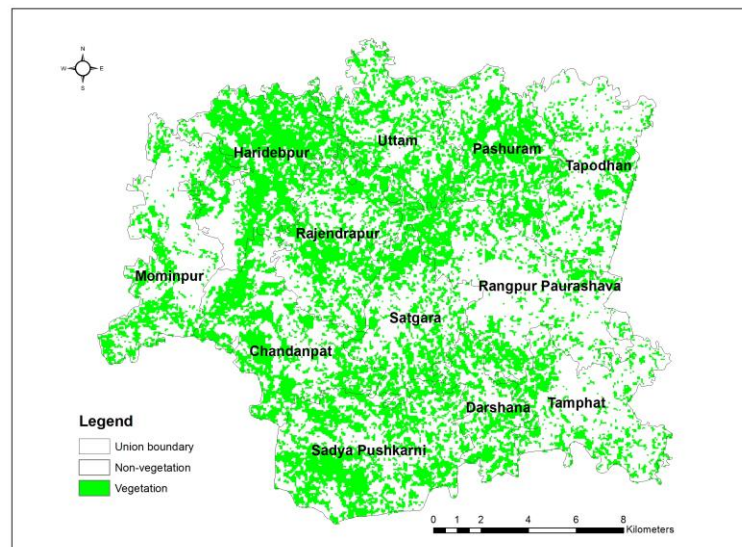


Figure 3. Urban vegetation coverage during 1972 in the study area.

5.2. Detection of Change in Vegetation

This study revealed the spatial pattern and characteristics of vegetation areas in the Rangpur Sadar Upazila. From 1972-1989, within 17 years, Mominpur, Rajendrapur, Satgara, Tapodhan unions had a little increasing tendency while other periods of time had experienced a decreasing trend in the total number of vegetation areas (Table 3). Most of the decreasing tendency was observed within the city center and its adjacent unions. Moreover, from 1972-2014, Chandanpat, Haridebpur, Rajendrapur and Sadya Pushkarni unions were lost vegetation areas drastically.

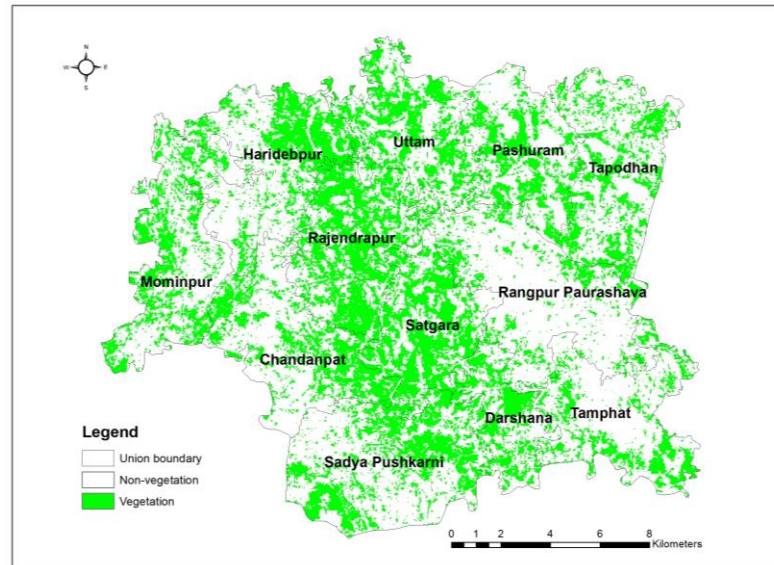


Figure 4. Urban vegetation coverage during 1989 in the study area.

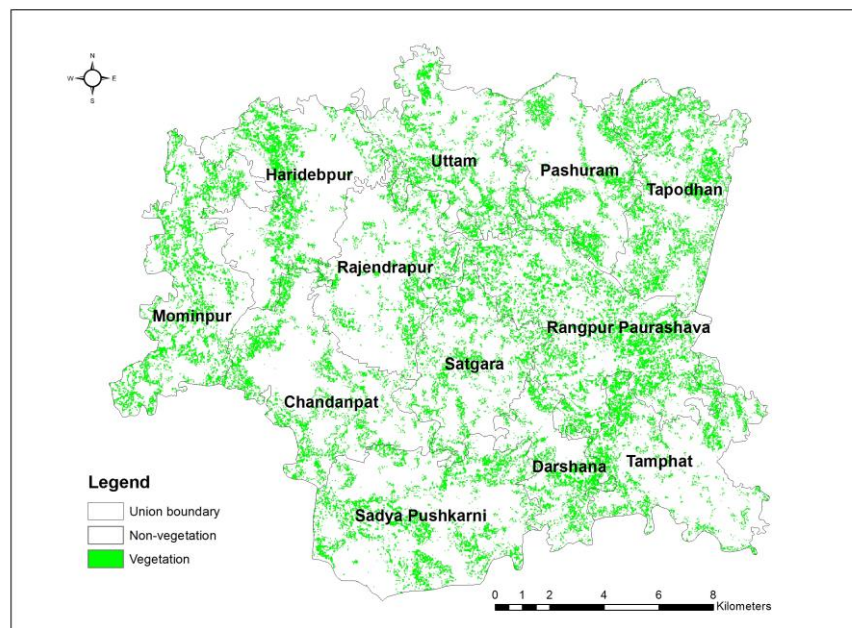


Figure 5. Urban vegetation coverage during 2014 in the study area.

5.3. Statistical Analysis

To observe a statistical relationship between the urban population and urban vegetation, a regression analysis executed using the city's union based urban population and union-wise extracted vegetation information using excel software. From this analysis, it is revealed that a robust relationship exists between the urban population and the urban vegetation in the Rangpur SadarUpazila. It means that if the population increase then the vegetation area will decrease simultaneously (Figure 6). In addition to this observation, regression analysis, $R^2=0.94$ represents a highly significant for this analysis as well.

Table 3. Total vegetation coverage during 1972, 1989 and 2014 in Rangpur Sadar Upazila

Union	1972-1989	1989-2014	1972-2014
Chandanpat	381	548	929
Darshana	25	308	333
Haridebpur	648	623	1271
Mominpur	-105	381	277
Pashuram	349	446	795
Rajendrapur	-287	1212	925
Sadya Pushkarni	464	752	1215
Satgara	-357	835	478
Tamphat	-35	252	217
Tapodhan	-226	274	49
Uttam	22	616	638
Rangpur Paurashava	419	-263	156

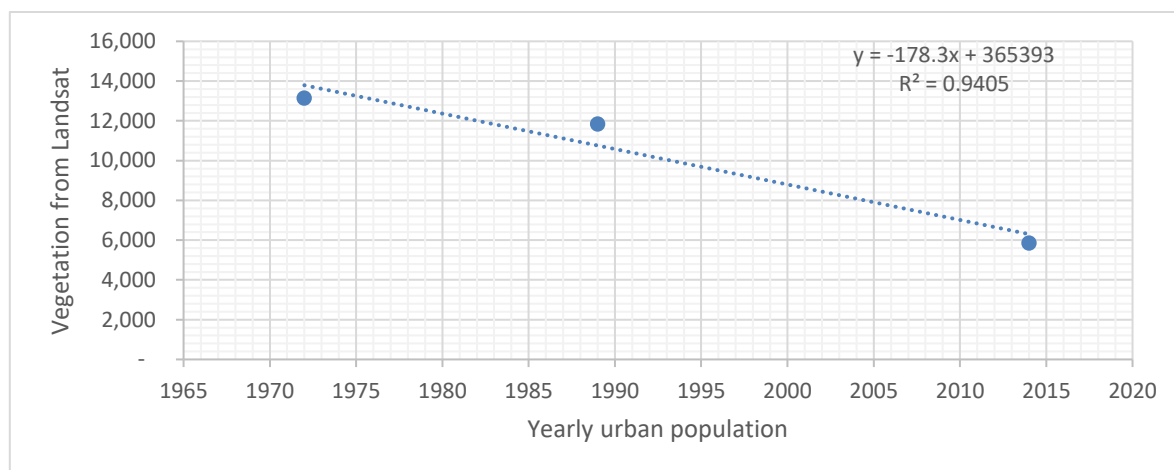


Figure 6. Regression analysis of urban population and urban vegetation in the study area.

5.4. Main Triggering Factors for Decreasing Vegetation

Similar to other developing countries, the number of migrant dwellers is increasing very fast in urban areas of Bangladesh. Growing urban population is mostly caused by rural urban migration and this displaced group of people finds their way into the urban informal settlements such as slums, squatters, footpaths, rail stations and other scattered places (ESCAP, 2007; Farhana *et al.*, 2012). Rangpur Sadar Upazila is also sprawling urban areas promptly in unplanned manner and the population increasing in high rate. A noteworthy portion of this region (Kurigram, Lalmonirhat and Gaibandha) consists of riverine char lands and people of those areas are severely affected by climate induced natural hazards including riverbank erosion and flooding. Such phenomenons mainly force them to migrate to this city. Besides, many marginalized people settle down in the city area in search of a better employment opportunity. In addition, Monga, a local short-term famine like seasonal food or drought, build burden on the affected people streaming into the city areas looking for food and labour activities (Sultana, 2010). The gradual changes of the vegetation pattern is very noteworthy since 1972 to 2014 in Rangpur Sadar Upazila and is clearly noticeable from the remote sensing data analysis (Islam *et al.*, 2016). Vegetation cover, bare lands and small water bodies have been converted into urban built-up in those areas. Unplanned urban development including inadequate housing triggered the factors for declining

vegetation. The local and the central responsible authority of the development board do not have any land reform policy along with land use monitoring system. Such land use practices will lead the region towards desertification in near future. Increasing urban population results in over-exploitation of the natural resources and put threats on environmental sustainability. The increasing level of local brick factories are also one of the major reasons behind loss of planted vegetation. They often use woods besides coal at brickfields.

5.5. Accuracy Assessment

A set of training data, about more than 7000 pixels, collected from the ground truth were used to run the accuracy assessment of the three classified NDVI images. The overall image accuracy assessment was 98%, 97% and 97% in 1972, 1989 and 2014 respectively. The total kappa co-efficient was 97%.

6. Conclusion

Vegetation has a significant role to restore urban ecology as well as to refrain negative effects from pollutions and Urban Heat Island (UHI). Urban vegetation can be a useful way to sustain green space concept. From this study, it is identified and quantified that a significant amount of vegetation areas has been decreased. Within 42 years, about 1297 hectare vegetation areas changed from 1972-1989; 5984 hectares from 1989-2014 and 7281 hectares from 1972-2014. It is also proved that interpretation of urban vegetation using NDVI of Landsat is very useful and substantial. The future methodology should be included with high resolution imagery, topographic information and other supplementary *in-situ* information. Due to rapid increasing of urban population, significant portion of vegetation cover areas, bare lands and small water bodies have been converted into urban built-up in Rangpur Sadar Upazila. The local responsible authorities do not have proper land reform policy, land use monitoring system and development planning. The present land use practices threat on environmental sustainability and will lead the region towards desertification in near future. It is highly recommended to prepare concrete land use policy for the area and keep natural vegetation protected. Certain areas should be reserved for forest creation and introducing tree plantation program would be highly encouraged. It is also necessary to identify and restore local water bodies and low lands. Therefore, it is urgent to create local awareness among people about the importance of having natural vegetation as well as natural water bodies. Ensuring sustainable development of the city, local city planners and other administration should follow the national urban land use and agriculture plan properly. Motivation to halt reducing urban vegetation needs to be rolled out by the government, non-government and local civil societies through a collective effort in the city.

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