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# FOREWORD

Conservation of environment is essential to ensure the security of water, food and energy for human beings. The challenges of environmental pollution, climate change and disasters must be addressed carefully with integrated initiatives, enhanced awareness and research. For deltaic landmass with vast coastal areas, the peoples of Bangladesh are the main sufferers of climate change and natural disasters. Therefore, interdisciplinary researches are utmost important for the control, mitigation, adaptation and dissemination of experiences for sustainable environmental management.

The Rajshahi University Journal of Environmental Science (RUJES) is a multi-disciplinary journal to promote understanding of environmental issues includes environmental pollution, biodiversity loss, emission of carbon dioxide from fossil fuel, climate change and their impacts on air, water, soil and ecosystem. Thus, the journal offers a scientific platform for publishing the critical reviews and original research achievements through peer-review.

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 current volume of the journal. I also thanks to 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 the Editorial Board do not bear any responsibility of the views expressed in the papers. The online version of the journal is available at: http://ru.ac.bd/ies

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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 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 proper interpretation and justification by relevant previous studies.
- **4**. **Conclusion:** Concise form of results with concluding remarks.
- **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.
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## The following format needs to follow for preparation of manuscript:

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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).

### 2.1. Second-Order Heading

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.

### 2.1.1. Third-Order Heading

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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.

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

### 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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Islam MB and Islam MS. 2006. Floods in Bangladesh: A Combined Interaction of Fluvio-anthropogenic Processes in the Sourse-sink Region, *In*: (Alphen JV, Beek EV and Taal M; eds): *Floods, From Defence To Management*. Taylor and Francis Group, London, England. P:589-595.

**For Book Edited**:

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

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**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*.

**For Regulation**:

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## CONTENTS

# Organic Geochemical Investigation of Permian Gondwana Shales from Drillhole GDH-46, Khalaspir Basin, Bangladesh: Implications for Source and Depositional Environment

**Quazi Hasna Hossain[1,2*], H. M. Zakir Hossain[1], Shigeyuki Suzuki[2], Yoshikazu Sampei[3], Toshiro Yamanaka[2,4], Yuji Onishi[2,5] and Md. Sultan-Ul-Islam[6]**

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## Abstract

Shales of fluvial deposits belonging to the Permian Gondwana Group, were collected from drillhole GDH-46 of the Khalaspir basin, northwestern Bangladesh, spanning the depth interval between 270 and 490 m from the surface. Here we present total organic carbon (TOC), total nitrogen (TN) and total sulfur (TS) contents, TOC/TN and TOC/TS ratios of 27 carbonaceous shale samples, in order to elucidate a significance of organic geochemical variations, sources and depositional environment of buried organic matter. The TOC and TN contents in the carbonaceous shale samples range from ~2 to 31 wt.% (average 7.64 wt.%) and 0.07 to 0.63 wt.% (average 0.27 wt.%), respectively. The TOC/TN ratios range between ~10 and 58 (average 26) indicate that organic matter in the studied shale samples were mostly originated from terrestrial vascular plants with minor input of algal derived organic matter. Furthermore, the strong positive correlation between TOC and TN ($r$ = 0.76) suggests a comparable organic matter source with some exceptional data in the plot area of high TOC contents. TOC/TS ratios for the Gondwana shale samples varied between ~67 and 2400 (average 598), indicating mainly oxic conditions prevailed during preservation of organic matter in the Khalaspir basin.

**Keywords:** Gondwana shale; Organic matter; TOC/TN ratio; Permian; Khalaspir basin; Bangladesh.

## 1. Introduction

Geochemical characteristics of organic matter in carbonaceous shale and coal provide important information related to the sources of organic matter, paleodepositional environments and paleoclimate fingerprints. Total organic carbon (TOC), total nitrogen (TN), total sulfur (TS) and their ratio values of sedimentary rock, sediment, and coal are widely used to identify organic carbon and nitrogen influx to the terrestrial/oceanic basin (Singh *et al.*, 2012; Ding *et al.*, 2018). Additionally, organic geochemical proxies of coals, and coaly shales or carbonaceous shales have provided to use as a guide for terrestrial carbon cycle in the globe, redox potential, land plant/planktonic sources and to reconstruct depositional environment (Bechtel *et al.*, 2007, 2018).

The Permian Gondwana sequence in the northwestern part of the Bengal Basin of Bangladesh contains abundant carbonaeous shales and coal seams (Islam *et al*. 1991; Norman, 1992; Uddin and Islam, 1992a; 1998; Bakr *et al*. 1996; Hossain *et al.*, 2000, 2002, 2013). The Gondwana coal in northwestern Bangladesh is sub-bituminous to bituminous in nature (Wardell-Armstrong, 1991; Norman, 1992; Bakr *et al.*, 1996). This Gondwana sequence has attracted the attention of geoscientists worldwide in different viewpoints, such as geology, lithostratigraphy and palynostratigraphy, sedimentology, geochemistry and coal-bed resource potential (Wardell-Armstrong, 1991; Islam 1993, 1994; Islam *et al.*, 1992; Hossain *et al.*, 2001, 2002; Islam and Hossain, 2006; Islam and Hayashi, 2008; Farhaduzzaman *et al.*, 2012; Hossain *et al.*, 2000, 2013, 2019, 2020; Islam *et al*. 2003, 2004a, b). The geochemical composition of Permian Gondwana coals (bituminous/sub-bituminous types) and shales around the globe have been investigated by numerous authors (Whiticar, 1996; de Wit *et al.*, 2002; Sarkar *et al.*, 2003; Bechtel *et al.*, 2007; Singh *et al.*, 2012; Ding *et al.*, 2018). However, there are only limited organic geochemical

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data published in nearby similar coal-bearing Gondwana basin in India (Sarkar *et al.*, 2003; Singh *et al.*, 2012; Ding *et al.*, 2018), and none of these studies have been conducted in the Gondwana sediments from drillhole GDH-46, Khalaspir basin in Bangladesh. Therefore, this is the first proxy report describing TOC, TN and TS contents in carbonaceous shales of northwestern Bangladesh to recover varied paleovegetation types and redox conditions during Permian age. This paper reports elemental compositions of carbonaceous shales in drillhole GDH-46, Khalaspir basin, Bangladesh, and highlights their potential input of organic matter source, vertical variations in elemental composition and depositional environment during evolution of the Gondwana succession.

## 2. Geological Setting

The Khalaspir basin is located in northwestern part of Bangladesh (Figure 1). This basin has an elongated fault bounded NW-SE trending composite outline with an area of approximately 25 km$^2$, and contains probable coal researves of about 685 Mt (Islam *et al.*, 1992; Uddin and Islam 1992b Hossain *et al.*, 2001, 2002). Eight coal seams were identified in the basin with a combined thickness of ~50 m, and the depth range between 257 and 483 m from the surface (Islam *et al*. 1992; Hossain *et al.*, 2002). This coal-bearing Gondwana sequence was accumulated during the Permian. Stratigraphic architectures of the Khalaspir basin are categorized as Gondwana Group, Surma Group, Dupi Tila Formation, Barind clay residuum, and alluvium in ascending order (Table 1). The Gondwana Group of Permian age is the oldest sedimentary succession in the Khalaspir basin. This Group composed of conglomerate, sandstone, shale and abundant coal. The sequences which are characterized by the finning upward successions of meandering river deposits are common. Feldspar is major in sandstone composition. Some sandstones and shales are calcareous due to formation of caliche. The conglomerate is predominant in the lower part of the Gondwana Group, which occurs in fluid flow or debris flow dominating braided river environment (Uddin and Islam 1992b; Hossain *et al.*, 2002). The coarse-grained sandstone in middle and upper part of this Gondwana Group is accumulated in braided river environment. The Miocene Surma Group is unconformably overlying the Gondwana Group, composed mainly of grey to dark grey mudstone, sandstone and pebbly sandstone (Hossain *et al.*, 2001). This Group was deposited in fluvial environment under channel-floodplain system (Islam *et al.*, 1992; Uddin and Islam 1992b; Hossain *et al.*, 2002). The Dupi Tila Group consists mainly of grey to yellowish grey sandstone, pebbly sandstone with uncommon mudstone (Table 1). The Pleistocene Barind Clay is unconformably underlying the recent alluvium, which is characterizing of weathering of floodplain deposits.

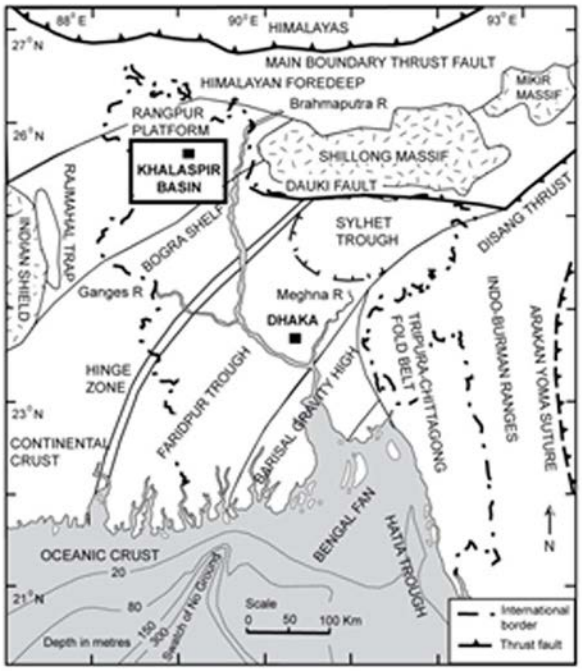


Figure 1. Generalized map showing location of the investigated area and major geologic features of the Bengal Basin and adjoining areas (modified after Hossain *et al.*, 2013, 2019).

Table 1. Generalized stratigraphic succession of coal-bearing Gondwana sequence in the Khalaspir basin, northwestern Bangladesh (After Islam *et al.*, 1992).

| Age | Group/Formation | Lithology | Max. Thickness (m) |
|---|---|---|---|
| Holocene | Alluvium | Grey sand and silty clay. | 4.26 |
| Pleistocene | Barind Clay | Yellowish grey silty clay. | 6.10 |
| Pliocene | Dupi Tila Formation | Grey to yellowish grey sandstone, pebbly sandstone with uncommon mudstone. | 162.12 |
| Miocene | Surma Group | Grey to dark grey mudstone, sandstone and pebbly sandstone. | 184.14 |
| Permian | Gondwana Group | Feldspathic sandstone, carbonaceous sandstone, carbonaceous shale, siltstone, mudstone, coal and conglomerate. | 814.93 + |
| | | Base not seen | |

## 3. Samples and Analytical Methods

### 3.1. Sampling

Twenty-seven carbonaceous shale samples (*ca.* 100 g) were collected from the drillhole GDH-46 in the Khalaspir basin, Bangladesh. The drilled core depth was nearly 500 m, and the sampling points covered a range from 274 to 487 m within the drillhole GDH-46 (Table 2). All given samples were then taken to the organic geochemical laboratory at Shimane University and Okayama University in Japan for analysis. The cleaned carbonaceous shale samples were pulverized using hand morter and pestle subsequently stored in the laboratory.

### 3.2. CNS Elemental Analysis

TOC, TN and TS analyses were performed on powdered carbonaceous shale samples with Elemental Analyzer (FISSION, EA 1108) at Shimane University, Japan. TOC and TN analysis of selected 22 carbonaceous shale samples were also conducted using an elemental analyzer (Euro EA3000, EuroVecrtor, Italy) at Okayama University, Japan. The powdered carbonaceous shales (ca. 10 mg) were pre-treated with l M HCl at room temperature to remove inorganic carbonate subsequently drying at 40 °C. The TOC and TN values were reported as weight percentage (wt.%). The analytical uncertainity (coefficient of variation) of TOC and TN was about ± 0.3 wt.%.

## 4. Results

The TOC, TN and TS contents, and TOC/TN and TOC/TS ratio values of the Permian Gondwana carbonaceous shales were presented in Table 2 and their vertical variations were illustrated in Figure 2.

The ash content varies between 54% and 89%, averaging 81% (Figure 2). The TOC and TN of the carbonaceous shales vary widely from 0.04 to 30.6 wt.% (average 7.64 wt.%) and 0.07 to 0.63 wt.% (average 0.27 wt.%), respectively. TOC values were more varied throughout the sequence, and high values (KB-14a) in the middle part at 366 m, and decrease significantly (<10 wt.%) after 415 m depth from the surface (Figure 3a). The extremely low TOC (0.04 wt.%) was also observed in sample KB-22 at a depth 432 m. Similarly, high TN values (upto 0.63 wt.%) were also evident in the same sample (KB-14a; Figure 3b). This discrepancy may be related to the changes of varied organic source materials input into the basin. However, TOC/TN ratios range from ~10 to 58.1 (average 26) and high value in the sample KB-09 while low value was observed immediately above the sample KB-08. Similarly, TOC/TS ratios range between 14 and 2400 with a high maximum value was seen sample KB-10 at 346 m depth interval.

Table 2. Result of CNS analyses for the carbonaceous shales from drillhole GDH-46, Khalaspir basin, Bangladesh.

| Sample No | Lithology | Depth (m) | Ash (%) | TOC (wt.%) | TN (wt.%) | TS (wt.%) | TOC/TN | TOC/TS |
|---|---|---|---|---|---|---|---|---|
| KB-01 | Black shale | 274 | 80.9 | 7.62 | 0.30 | 0.06 | 25.7 | 136 |
| KB-02 | Black shale | 276 | 84.3 | 5.87 | 0.25 | [a]- | 23.4 | |
| KB-03 | Black shale | 286 | 73.8 | 13.11 | 0.46 | - | 28.4 | |
| KB-05 | Black shale | 295 | 83.2 | 6.43 | 0.29 | - | 22.3 | |
| KB-06 | Black shale | 302 | 74.7 | 13.79 | 0.60 | - | 23.0 | |
| KB-07 | Black shale | 309 | 77.9 | 12.14 | 0.40 | 0.01 | 30.6 | 2400 |
| KB-08 | Black shale | 319 | 86.5 | 6.11 | 0.63 | - | 9.6 | |
| KB-09 | Black shale | 338 | 78.9 | 11.20 | 0.19 | - | 58.1 | |
| KB-10 | Weathered sandstone | 346 | n.a. | 1.97 | 0.07 | 0.15 | 27.6 | 14 |
| KB-11 | Black shale | 356 | 75.2 | 11.31 | 0.45 | - | 25.1 | |
| KB-13(a) | Black shale | 361 | 70.5 | 15.03 | 0.33 | - | 45.2 | |
| KB-14(a) | Black shale | 366 | 54.3 | 30.57 | 0.59 | 0.13 | 51.9 | 239 |
| KB-14(b) | Black shale | 385 | 73.3 | 9.56 | 0.30 | 0.14 | 32.3 | 67 |
| KB-15 | Black sandy shale | 391 | 82.7 | 4.83 | 0.18 | - | 26.5 | |
| KB-16 | Black shale | 408 | 83.4 | 3.05 | 0.15 | - | 19.7 | |
| KB-18 | Black shale | 415 | 71.3 | 16.81 | 0.39 | - | 42.6 | |
| KB-19 | Black shale/siltstone | 416 | 80.9 | 7.23 | 0.24 | 0.01 | 30.7 | 734 |
| KB-20 | Black shale | 423 | 85.5 | 5.28 | 0.15 | - | 36.0 | |
| KB-21 | Black shale | 428 | 85.8 | 0.87 | 0.12 | - | 7.5 | |
| KB-22 | Black shale/siltstone | 434 | 87.9 | 0.04 | 0.08 | - | 0.4 | |
| KB-23 | Black shale | 444 | 80.9 | 7.53 | 0.23 | - | 33.2 | |
| KB-26 | Black shale | 451 | 85.3 | 6.27 | 0.19 | - | 32.2 | |
| KB-28 | Black shale | 460 | 87.5 | 2.37 | 0.14 | - | 17.3 | |
| KB-31 | Black shale | 468 | 84.7 | 2.77 | 0.16 | - | 17.7 | |
| KB-33 | Black sandy shale | 474 | 89.3 | 1.66 | 0.12 | - | 13.6 | |
| KB-35 | Black sandy shale | 479 | 89.0 | 0.29 | 0.09 | - | 3.1 | |
| KB-36 | Black sandy shale | 487 | 88.1 | 2.62 | 0.20 | - | 13.1 | |

"a", below detection limit; "n.a.", not analyzed.

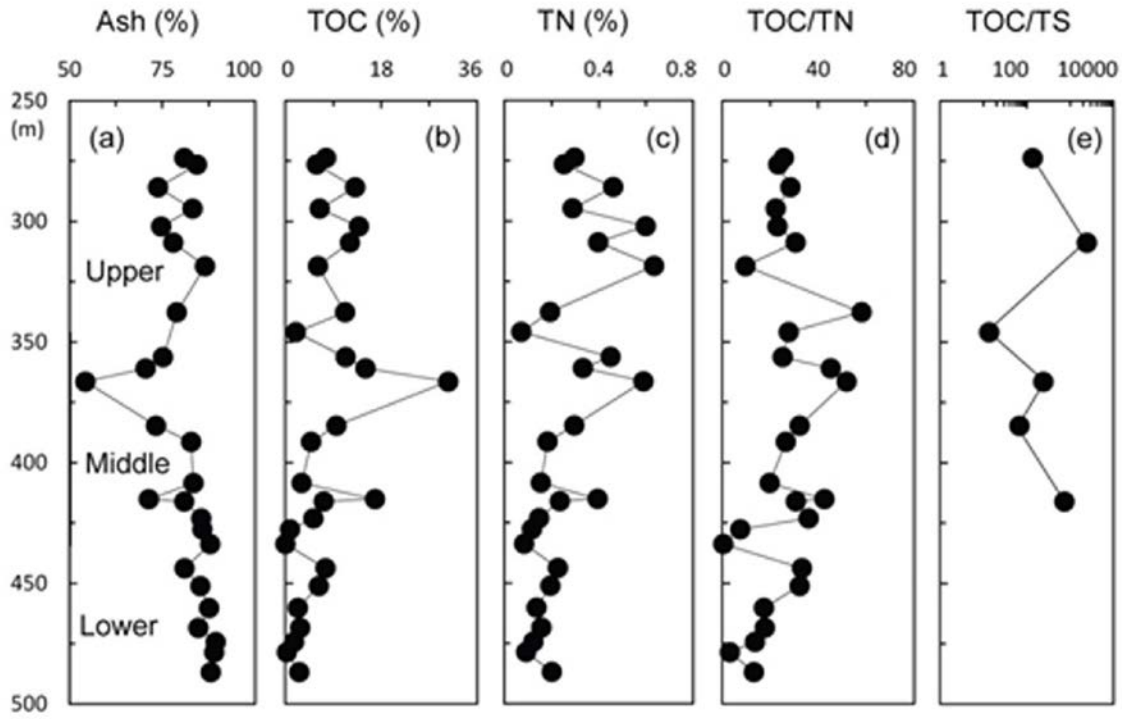


Figure 2. Vertical variations in ash, TOC, TN, TOC/TN, and TOC/TS data in the Permian Gondwana carbonacous shales, Khalaspir basin, Bangladesh.

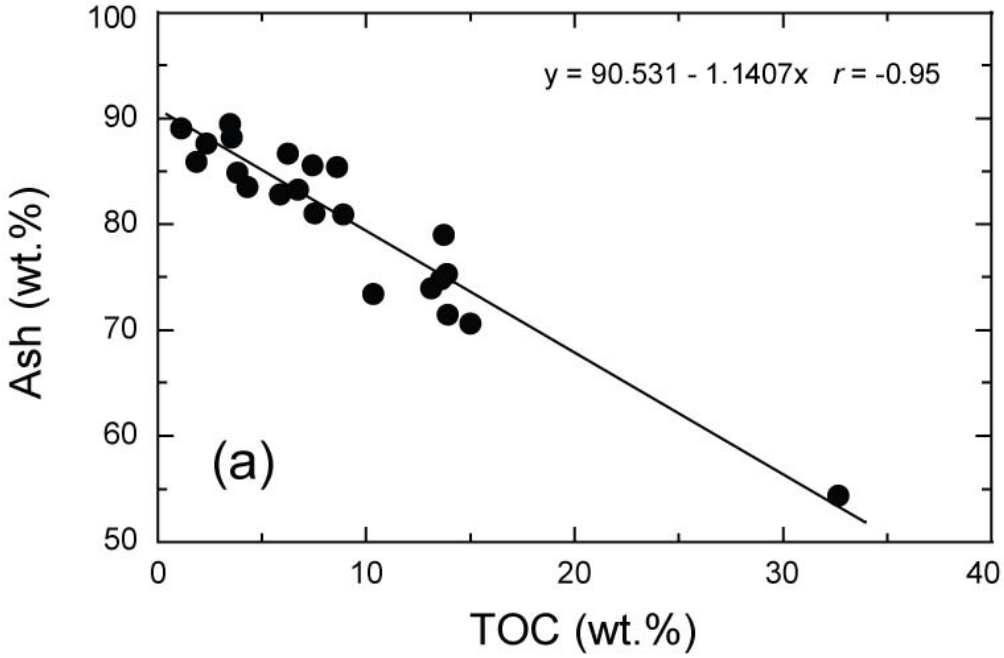


Figure 3a. Variation diagrams for source identification in Permian Gondwana carbonaceous shales in the Khalaspir basin, Bangladesh: TOC–Ash.

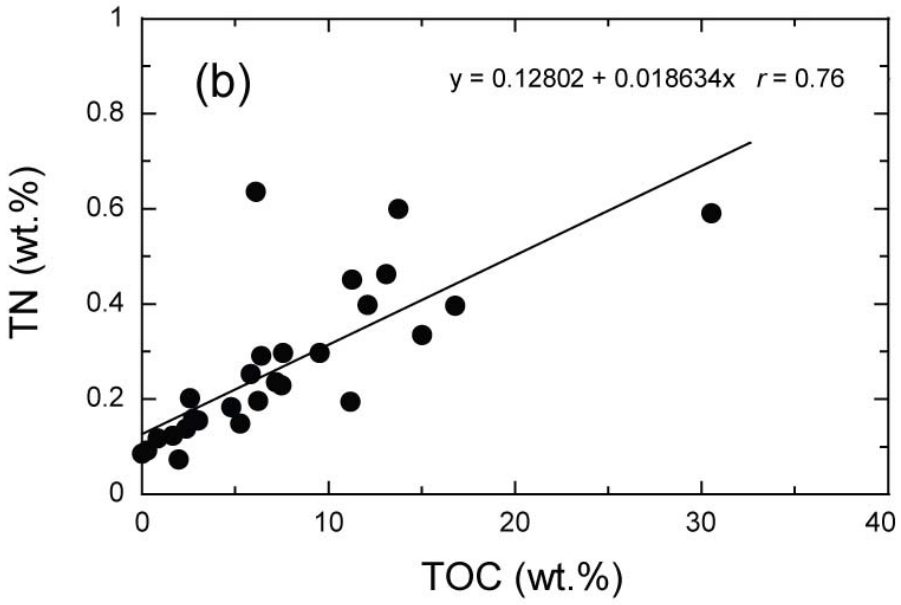


Figure 3b. Variation diagrams for source identification in Permian Gondwana carbonaceous shales in the Khalaspir basin, Bangladesh: TOC–TN.

## 5. Discussion

### 5.1. Sources of Organic Matter

The accumulation of organic carbon in sedimentary basin is primarily controlled by the influences of several aspects such as surface productivity, organic matter fluxes to the benthos, exposure to effective oxidants, rate of sedimentation and/or varied depositional conditions (Keil *et al.*, 1994; Blair and Aller, 2012). The geochemical records show that the investigated Gondwana succession can be divisible into three parts based on the wide variation of organic carbon contents, such as lower (274-346 m), middle (356-434 m), and upper (444-487 m: Figure 2). The carbonaceous shales are characterized high ash yields which differ between 54% and 89%. The TOC contents in the carbonaceous shales vary significantly (0.04-30.57 wt.%), and high values (upto 30.57 wt.%) were observed in the upper- and middle parts of the sequence. The lower part contained comparatively lower TOC contents (0.29-7.53 wt.%), whereas ranges were high in the middle part (0.04-30.57 wt.%) and slightly higher in the upper part (1.97-13.79 wt.%). These features suggest that a diverse origin of organic matter preserved in the basin. The correlation between TOC and ash contents is negative ($r$ = -0.95; Figure 3a) with increasing ash and decreasing TOC, indicating that ash may be controlled by the input of clastic materials in the basin owing to the periodic fluctuation of water table or of seasonal flooding. The TN values varied between 0.07 to 0.63 wt.%, and TN correlated well with TOC ($r$ = 0.76; Figure 3b) and show a marked linear trend suggesting a comparable organic matter source (Hossain *et al.*, 2017) excluding 302 m and 319 m with high TN contents. The TOC/TN ratio has been widely used to discriminate terrestrial and marine derived organic matter stored in sedimentary basins (Bordovskiy, 1965; Meyers and Ishiwatari, 1993; Meyers, 1994; Thornton and McManus, 1994; Sampei and Matsumoto, 2001). Marine organic matter (primarily phytoplankton and zooplankton) usually contained TOC/TN ratios of 5-7 (Bordovskiy, 1965; Meyers, 1994), whereas terrestrial derived organic matter (mostly higher plants) has TOC/TN ratios higher than 12 (Meyers, 1994; Tyson, 1995; Hedges *et al.*, 1997). The intermediate TOC/TN ratios (~10) signify mixed marine/aquatic and terrestrial origin of organic matter (Stein, 1991). Generally, TOC/TN values in C3 vascular plants are ~12 and higher (Tyson, 1995), while C4 grasses typically have TOC/TN values of >30 (Meyers, 1994). The TOC/TN ratios in the carbonaceous shales varied between ~20 and 81, with averaging 26 (Table 2) indicate terrestrial derived organic matter input to the basin (e.g., vascular plant leaves, grasses and macrophyte). Terrestrial higher plants have relatively low TOC/TN ratios about 30 for leaves, high about 90 for stems and very high about 150 for roots (Tang *et al.*, 2018). *Sphagnum* has TOC/TN ratios of 48-89 (Kuhry and Vitt, 1996). Therefore, organic matters of the present study carbonaceous shales are possibly from leaves and stems of vascular plants and/or *Sphagnum*. Two samples also contained

relatively lower TOC/TN ratios (<10.1) with high TN content inferring a mixed source of algal/nonvascular plants and vascular land plants (Stein, 1991; Meyers and Ishiwatari, 1993). Unusually low TOC/TN ratios (<4) in sediments sometimes show the inorganic nitrogen effect as $NH_4^+$ probably absorbed by alluminosilicate clay minerals, especially when the TN contents were low in the sediments (Müller, 1977; Sampei and Matsumoto, 2001). In contrast, TOC/TN ratio is exceptionally low in one sample (0.4; KB-22) at 434 m depth intervals, indicating that inorganic nitrogen possibly effects to reduce TOC/TN ratio in the sample. A single sample has relatively low TOC/TN ratios (9.6), suggesting aquatic algal or planktonic organic matter contribution to the sample and/or enhanced diagenetic effect (Möbius *et al.*, 2011; Selvaraj *et al.*, 2015).

### 5.2. Depositional Environment

The TOC/TS ratios have been widely used as proxy to evaluate marine/non-marine and oxic/anoxic water-bottom conditions during sedimentation in the basin (Berner, 1982; Berner and Raiswell, 1984). Low TOC/TS ratios (<3, Berner, 1982 or 0.5-5, Berner and Raiswell, 1984) indicate organic matter deposited in marine anoxic conditions. In this study, TOC/TS ratios for the carbonaceous shales varied from ~67 to 2400 (average 598; Figure 2e and Table 2), reflecting mainly oxic low saline water or freshwater conditions prevailed during accumulation of organic matter in the Khalaspir basin.

## 6. Conclusions

The carbonaceous shales of Permian Gondwana Group, were collected from drillhole GDH-46 of the Khalaspir basin, Bangladesh, in order to evaluate organic geochemical variations throughout the stratigraphy, sources of organic matter, and paleodepositional environment during accumulation of organic matter in the sedimentary basin. Abundances of TOC and TN in the carbonaceous shale samples varies from ~1 to 31 wt.% (average 7.64 wt.%) and 0.07 to 0.63 wt.% (average 0.27 wt.%), respectively. The TOC/TN ratios varied between ~10 and 58 (average 26) suggest that organic matter in the Khalaspir basin were typically initiated from terrestrial higher plants with negligible contribution of algal organic matter. The strong positive correlation between TOC and TN ($r$ = 0.76) recommends a similar organic matter source. The TOC/TS ratios in the shales imply oxic environment conditions existed during preservation of organic matter in the Khalaspir basin. However, overall observation suggests that the organic matter in the Gondwana carbonaceous shales was primarily derived from terrestrial higher plants, and deposition occurred in oxic conditions over the Gondwanaland.

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# Reduction of Vegetation Cover in Rajshahi City Corporation of Bangladesh

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## Abstract

Multi-temporal Landsat TM/OLI satellite images have been used for the years 2000, 2010 and 2020, to classify Land Use/Land Cover (LULC) classes, a transformation between vegetation cover (VC) to an urban area (UA), directional distribution of Urban area (UA) and Vegetation Cover (VC), and variation of Land Surface Temperature (LST) in the study area. The supervised maximum likelihood classification algorithm has been used to classify the LULC maps. All the classified LULC maps demonstrated an overall accuracy of more than 85%. The spectral radiance model has been used to extract LST information from satellite images. The LULC estimation analysis suggested a significant net increase in UA areas (+15.55%) and a reduction in VC (-19.42%) from the year 2000 to 2020 respectively. The maximum temperature of the city increased to 37.75 $^0$C in 2020 from 27.76 $^0$C in 2000. The assessed LST showed that lower recorded temperature zones in 2000 converted into a higher temperature zone in 2020. The mean LST distribution shows growing trends and increases in UA, and reduction in VC converted the study region from a moderate temperature zone to the high-temperature zone. The study clearly show that a rise in the non-evaporated surfaces, i.e., UA and a reduction in the green cover has significantly increased the LST effect in the study area.

**Keywords:** Vegetation Cover; Land Surface Temperature; Remote Sensing; Rajshahi City Corporation

## 1. Introduction

The need for natural resources is increasing day by day with the rapid population growth in an urban area. It seems that this situation puts increasing pressure on the natural habitat (FAO, 1997). In this regard, Land Use/Land Cover (LULC) changes should be considered as the most basic information in land management (Varun *et al*., 2016). One of the most critical indicators of urbanization is the increase of land surface temperature (LST) with the anthropogenic heat effect and the formation of urban heat island (UHI) (Kumar *et al*., 2012). Metropolitan cities are warmer compared to surrounding rural areas (Huidong *et al*., 2018). The main reason for the formation of urban heat is warming the land surface with the effect material involving the heat due to urban development (Kaya *et al*, 2012) and removing vegetation covers.

The rapid unplanned transformation of vegetation cover (VC) to an urban area (UA) dramatically affects the ecosystem and biodiversity functions. LULC and LST play a crucial role in modeling the Earth's surface hydrological, ecological, agricultural, and climate processes (Meyer and Turner, 1992; Lo and Quattrochi, 2003; Kafy *et al.*, 2020). LULC changes accelerated by rapid urbanization and created significant effects on LST (Rahman *et al.*, 2017a; Niyogi, 2019). LST's dynamic increment creates an Urban Heat Island (UHI) effect (Ningrum, 2018; Kafy *et al.*, 2019b). Anthropogenic heat emission increases the land's surface temperature due to its high energy consumption and subsequent decreases in vegetation and water-permeable surfaces, thereby decreasing surface temperature through evapotranspiration (Lo and Quattrochi, 2003; Chen *et al.*, 2006). Thermal Remote Sensing (RS) data can be used to extract the spatially distributed LSTs in clear-sky conditions by calculating the upward longwave radiation from the surface area (Hart and Sailor, 2009; Bharath *et al.*, 2013). The thermal signal acquired by RS sensor at the top of the atmosphere (TOA) is influenced by temperature and land surface emissivity parameters (Bokaie *et al.*, 2016).

In addition to the provision for radiant surface temperature measurements, remote sensor instruments are also used to measure energy reflectance in the red and near-infrared portions of the electromagnetic spectrum, which can be used to quantify changes in vegetation conditions (Anbazhagan and Paramasivam, 2016). The lower LSTs are usually found for dense vegetative areas, but they can differ in times, locations, and vegetation distribution

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types. Weng *et al*. (2004) found a slightly stronger negative correlation of the vegetation fraction to LST. Yue *et al*. (2007) have indicated a significant difference in the mean LST and normalized differential vegetation index (NDVI) values associated with different land uses. Joshi and Bhatt (2012) reported the temperature in areas with vegetation and water sources is lower than in built-up areas. Sun and Kafatos (2007) found that the correlation of LST and NDVI in the winter is positive and in warm seasons is negative.

The victims of climate change are developing and underdeveloped countries (IPCC, 2014). As a developing country, Bangladesh is one of the world's most vulnerable to climate change. The northwestern region of Bangladesh showed a signature of climate change (World Bank, 2016). LSTs are gradually increasing in this region, influenced by urbanization, global warming, and climate change (IPCC, 2014; Hossain *et al.*, 2020). Several research studies have been conducted concerning the climate change scenarios based on the temperature, but the influence of vegetation dynamics on LST studies are limited. Kafy *et al* (2020a) reported an increase in the mean LST over the past two decades (1999-2009) by $9.83^0$C and $13^0$C in the city and district of Rajshahi respectively. Ahmed and Ahmed, 2012 have been reported an increase in temperature in Bangladesh about $0.5^0$C. Rahman and Lateh (2017) found that during the June-August period, the temperature generally increased. The average maximum and minimum temperatures showed an increasing trend, respectively, of $5^0$C and $3^0$C. They also opined for the December-February period, the average maximum and minimum temperatures showed a decreasing and increasing trend of 0.1 $^0$C and $1.6^0$C respectively.

Geographic Information System (GIS) and RS techniques used as one of the most effective approaches in identification of the dynamics of VC losses and its impacts on LST in any area (Gallo and Tarpley, 1996; Balzter, 2000; Amiri *et al.*, 2009; Anbazhagan and Paramasivam, 2016). VC loss's impacts on surface temperature can be easily estimated using classification techniques and spatial analysis toolsets,. The study aims to identify the VC losses using a Supervised Classification Technique (SCT) and evaluate their impacts on LST retrieved from Landsat $5^{TM}$ and Landsat 8 OLI Images in Rajshahi City Corporation (RCC). It is anticipated that the study will help urban planners and policymakers to identify and take effective measures in mitigating the LST effects by increasing the VC in the study area.

## 2. Materials and Method

### 2.1. Study Area

The city of Rajshahi is the social, economic, and administrative hub of northern Bangladesh situated on the north bank of the Ganges River having geographical coordinates 24° 12′ to 24° 42′ N latitude and 88° 15′ to 88° 50′ E longitude in the northwestern region of Bangladesh (**Figure 1**). The study area is nearly flat, with a surface elevation between 15 and 19 m.

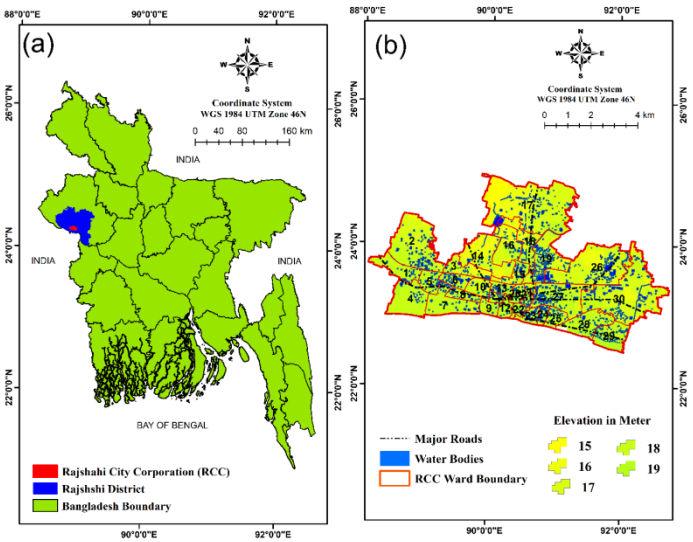


Figure 1. Location Map of Bangladesh (a) and Rajshahi City Corporation (RCC) (b) showing wards boundary, road network, and elevation (estimated from SRTM/ DEM)

The dry-wet tropical monsoonal prevails in RCC with a maximum temperature varies from 30-35 $^0$C and having an annual average rainfall of 1448 mm (Ferdous and Baten, 2011; Kafy *et al.*, 2020a). Since the last few decades, the city is facing rapid urbanization. Along with rapid urbanization and regional climate change phenomenon has drastically altered the duration and behavior of winter and summer seasons. This has detrimental effects on the cities climate, livelihood and green cover development (Kafy *et al.*, 2020b). Land-use history in this area shows that over 19% of the green cover area has been lost. An increment in maximum LST was about 9$^0$C in the last 20 years due to rapid urbanization (RDA, 2003, 2008; Kafy *et al.*, 2019c; Kafy *et al.*, 2020b).

### 2.2. Data

For the present research two decades viz., years 2000, 2020, and 2020 have been selected. Three Multi-spectral Landsat Satellite data were collected from the United States Geological Survey (USGS) domain for estimating the changes in VC and LST dynamics in the study area. All of these images are downloaded (**Table1**) for the month of April to prevent the influences of seasonal variations(Kafy *et al.*, 2017; Kafy & Ferdous, 2018; Kafy *et al.*, 2019a; Kafy *et al.*, 2020a). In the image downloading process, maximum cloud coverage was set to less than 10% for ensuring a realistic estimation of LULC and LST. However, across the study region, it was near to zero percent. No additional geo-correction or image processing required for the preprocessing of images, since the Landsat Satellite data is free of radiometric and geometric distortions. Images details were gathered from the USGS repository.

Table 1. Description of the sensors

| Satellite data | Date of acquisition | Sensor | Path/Row | Band No. | Spectral range (Wavelength $\mu$m) | Spatial resolution, m |
|---|---|---|---|---|---|---|
| Landsat 4-5 | April 15, 2010; April 11, 2010 | TM | 138/43 | 1 | 0.45–0.52 | 30 |
| | | | | 2 | 0.52–0.60 | 30 |
| | | | | 3 | 0.63–0.69 | 30 |
| | | | | 4 | 0.76–0.90 | 30 |
| | | | | 5 | 1.55–1.75 | 30 |
| | | | | 6 | 10.40–12.50 | 120 resample to 30 |
| | | | | 7 | 2.08–2.35 | 30 |
| Landsat 8 | April 6, 2020 | OLI. | 138/43 | 1 | 0.43–0.45 | 30 |
| | | | | 2 | 0.45–0.51 | 30 |
| | | | | 3 | 0.64–0.67 | 30 |
| | | | | 4 | 0.53–0.59 | 30 |
| | | | | 5 | 0.85–0.88 | 30 |
| | | | | 6 | 1.57–1.65 | 30 |
| | | | | 7 | 2.11–2.29 | 30 |
| | | | | 8 | 1.36–1.38 | 15 |
| | | | | 9 | 0.50–0.68 | 30 |
| | | | | 10 (TRIS1) | 10.60–11.19 | 100 resample to 30 |
| | | | | 11 (TRIS 2) | 11.50–12.51 | 100 resample to 30 |

**Source:** (https://earthexplorer.usgs.gov)

### 2.3. Landcover Classification

The satellite images obtained from Landsat sensors were enhanced in Erdas Imagine V.15 software by 3*3 majority filtering technique for better visibility (Kafy *et al.*, 2020b; Kafy *et al.*, 2020a). True Color Composite (TCC.) was generated using the correct band combinations for all images to choose training samples of various LULC classes (Trolle *et al.*, 2019; Kafy *et al.*, 2020a). The collected Landsat images were classified into four LULC categories Urban area, Vegetation cover, Water bodies, and Bare land for the years of 2000, 2010, and 2020 (Table 2). Maximum Likelihood Supervised Classification (MLSC) technique used to estimate the LULC classification. In the process of creating LULC maps, about 25 training samples were taken for each LULC class.

Accuracy of land cover maps is measured from available field data and Google Earth images through 150 ground truth points. Kappa statistics and Confusion Matrix are considered one of the best indicators for image classification accuracy were used in the study for accuracy assessment of the classified LULC maps (Story and Congalton, 1986; Foody, 2002; Congalton and Green, 2008; Pontius Jr and Millones, 2011).

Table 2. Descriptions of LULC classes

| LULC Classes | Description |
|---|---|
| Urban area | Residential, commercial and industrial services, transportation network. |
| Vegetation cover | Trees, grassland, cropland, and fallow land. |
| Water Bodies | River, wetlands, lakes, ponds, and reservoirs. |
| Bare Land | Vacant land, open space, sand, bare soils, and landfill sites. |

### 2.4. Land Use/Land Cover Transformation

The transformation of one LULC to another LULC is essential to identify the most dominated LULC class in the study area. As the study aims to identify the changes of VC influence by urban development, the "combined" technique under "spatial analyst toolset" in Arc GIS 10.6 software used to estimate the transformation rate of VC pixel to the UA from 2000-2010, 2010-2020 and 2000-2020 respectively. The combined toolchains multiple rasters so that a unique output value is assigned to each unique combination of input values (Figure 2).

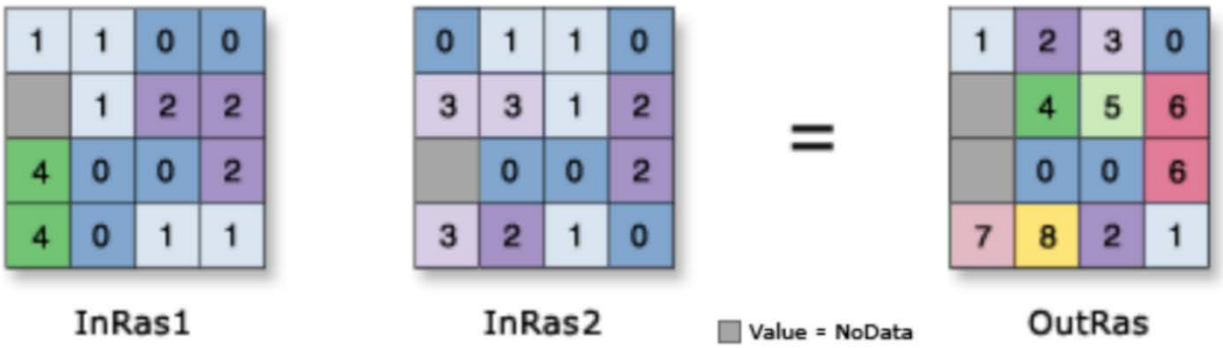


Figure 2. Illustration process of combined tool process in Arc GIS 10.6 software

### 2.5. Estimation of Land Surface Temperature

Using the digital numbers (DN) of the thermal bands (Band i6 in Landsat $5^{TM}$ and Bands10 in Landsat 8TIRS),the LST was estimated. The spectral radiances(λ) of the Landsat $5^{TM}$ and Landsat 8TIRS bands were computed at the preliminary phase, by using the equation(1) and equation(2), respectively. $L_\lambda$ was used to derive the LST in Degree Celsius using the equation (3).

$$L_\lambda(LANDSAT\ 5\ TM) = L_{min} + \frac{L_{max} - L_{min}}{Qcal_{max} - Qcal_{min}} \times DN \quad (1)$$

$$L_\lambda(LANDSAT\ 8\ OLI) = ML \times DN + AL \quad (2)$$

$$LST = \frac{T_B}{1 + \left(\lambda \times \frac{T_B}{\rho}\right) * \ln(\varepsilon)} - 273.15 \quad (3)$$

Where, ML (0.0003342) is a multiplicative rescaling factor (band-specific),and AL (0.1) is an additivere scaling factor (band-specific).The values for LandsatTM, $L_{max,}$ and $L_{min}$ were collected from the satellite meta data file. The wave length of emitted radiance λ is11.5μm (Kumar *et al.*, 2012; Rahman *et al.*, 2017b; Aboelnour and Engel, 2018; Ullah *et al.*, 2019; Kafy *et al.*, 2020a).

$$\rho = \frac{h \times c}{\sigma} = 1.438 \times 10 - 2 \text{ mK} \quad (4)$$

Where, h indicates Plank's constant which is equal to 6.626×10-34Js, c indicates the velocity of light, which is equal to 2.998×108ms$^{-2}$ and $\sigma$is the Boltzmann constant (5.67×10-8 iWm2k-4 i=1.38×10-23JK$^{-1}$); ε is the land surface emissivity which ranges in between 0.97 to 0.99 (Mallick *et al.*, 2008; Pal and Ziaul, 2017; Guha *et al.*, 2018).

$$T_B = \frac{K_2}{\ln(\frac{K_1}{L_\lambda} + 1)} \quad (5)$$

Where $T_B$ is the satellite brightness temperature, and the constants $K_1$ and $K_2$ values for (1) Landsat-5:$K_1$ is 607.7, and $K_2$ is 1260.6 and (2) Landsat8:$K_1$ is 774.9 and $K_2$ is 321.07, respectively (Anbazhagan and Paramasivam, 2016; Ullah *et al.*, 2019; Kafy *et al.*, 2020a; Roy *et al.*, 2020).

### 2.6. Temperature Variations in the Urban Area and Vegetation Cover

To establish the relationship between LULC and LST, the temperature variation in different land use is important. The "Tabulate area" technique under zonal toolset in Arc GIS 10.6 was used to estimate the LST variation over different LULC classes. The tool calculates cross-tabulated areas between two datasets and outputs a table. Ward wise zone data is defined as all areas in the input that have the same value. The areas do not have to be contiguous. Both raster and feature can be used for the zone input. The vegetation and UA data was used as class raster in the tabulate area process.


Figure 3. Illustration process of Tabulate area tool in Arc GIS 10.6 software

## 3. Result and Discussion

### 3.1. Changes in LULC Classes

To determine the LULC change patterns over the past two decades, the MLSC algorithm is applied. The classification accuracy was estimated using user accuracy, producer accuracy, kappa coefficient and overall accuracy. The classification accuracy demonstrates an excellent result with more than 85% accuracy in all parameters for different years.

Two significant patterns of changes are noticeable in classification results during the study period. One is a gradual increase in UA and a considerable decrease in VC. As represented graphically (Fig 4) and statistically (Table 3), over the last two decades + 15.55% of the UA and + 6.45% of bare land increased resulting - 19.42% and - 5.59% decrease in VC and water bodies, respectively in the study area. Several influential factors such as unplanned growth, urban pull factors, better study opportunity and being the divisional economic hub accelerate such LULC changes all over the area (Regmi *et al.*, 2014; Rahman, 2016; Fernando, 2018; Silva *et al.*, 2018; Anand and Oinam, 2020; Kafy *et al.*, 2020b; Kafy *et al.*, 2020a).

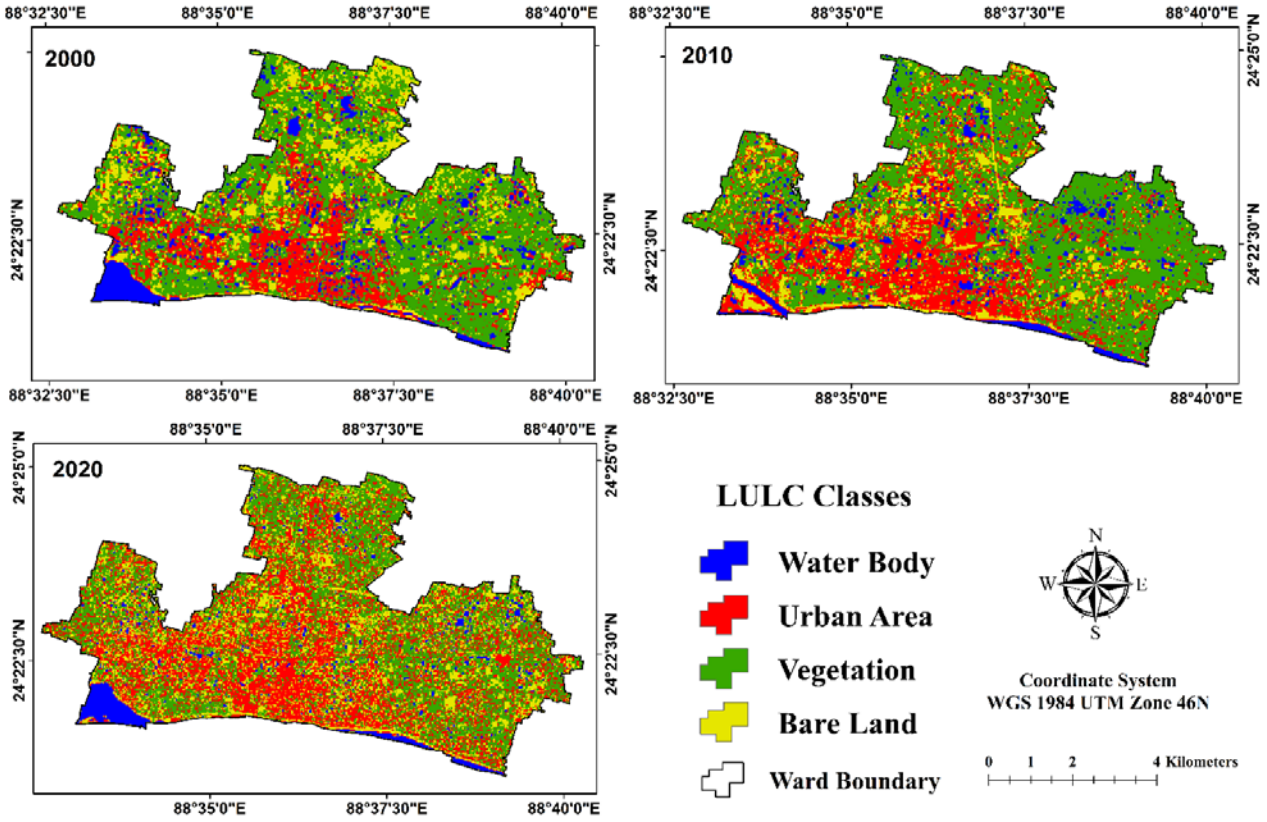


Figure 4. Land use/Land cover distribution in Study area

Table 3. Area ($Km^2$) and Net change (%) Variations of Land use/Land Cover of the study area.

| LULC | Area ($Km^2$) | | | Net Change (%) | | |
|---|---|---|---|---|---|---|
| | 2000 | 2010 | 2020 | 2000-2010 | 2010-2020 | 2000-2020 |
| Water Body | 4.78 | 4.53 | 3.52 | -0.51 | -2.08 | -2.59 |
| Urban | 7.77 | 10.59 | 15.34 | 5.79 | 9.76 | 15.55 |
| Vegetation | 25.13 | 20.84 | 15.68 | -8.81 | -10.60 | -19.42 |
| Bare Land | 10.99 | 12.71 | 14.13 | 3.53 | 2.92 | 6.45 |

### 3.2. Urban Expansion and Vegetation Cover Loss

To identify the directional changes in UA and VC, 16 concentrated rings were drawn from the city center to outside the study area boundary at 5 km interval. The directional analysis is a standard method in summarizing the phenomenon of spatial-temporal urban expansion and VC loss pattern (Cao *et al.*, 2019; Kafy *et al.*, 2020a). The directional analysis detects that northwest, northeast and southeast directions rapid urban developmental changes have been taken places (Fig 5). Because of the rapid urban development, this direction also faced a significant decrease in VC. The estimated urban expansion and VC loss towards the northwest direction and along the Dhaka-Rajshahi highways is recorded as 15- 25% and 16-23% from the year 2000 to 2020 respectively. The northeast and southeast direction and along with Rajshahi - Naogaong and Rajshahi - Chapai highway have been experienced comparatively less urban expansion and VC loss ranging from 5-12% and 3-4% in the last 20 years. The development towards the northwest direction was significant since residential and commercial activities were more easily accessible. Several development projects such as new road construction, new commercial buildings, and less than 5km$^2$ from train and bus station have enhanced northwest urban growth and contribute to VC's replacement in the study area.

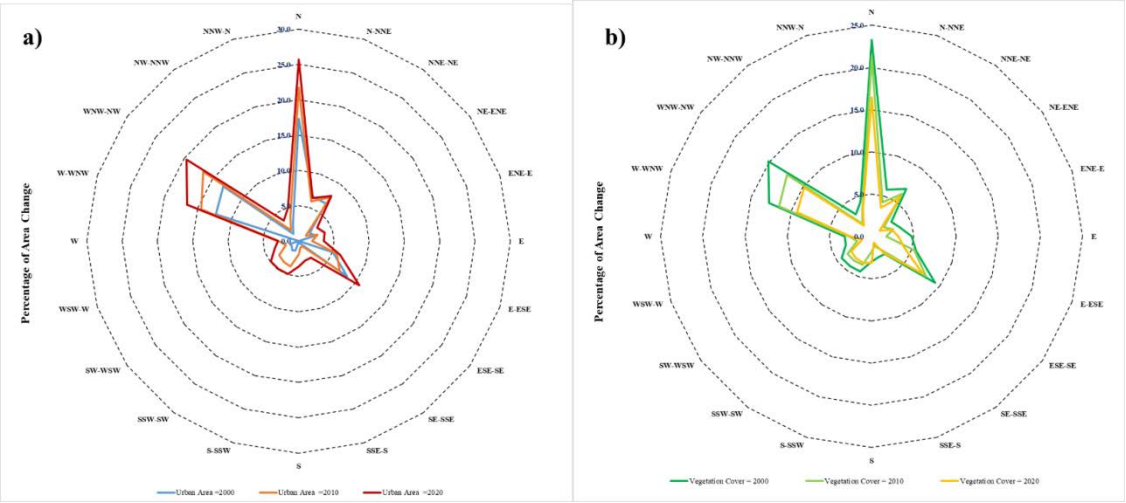


Figure 5. Directional changes of a) urban area and b) vegetation cover in the study area from 2000-2020.

### 3.3. Transformation of Vegetation Cover into Urban Area

A transition map of VC to UA is estimated for the year 2000, 2010, and 2020, respectively (Fig. 6). It estimated that 10%, 28% and 26% of VC transformed into UA from the mentioned years. The conversion rate of vegetation cover to UA is more than doubled in the last 20 years. The analysis reveals the dominance of urban development in the previous two decades in the study area.

### 3.4. Variations of Land Surface Temperature

The LST variation and aerial distribution in the study area are represented in Tables 4 and 5 and illustrated in Figure 7 for the years 2000, 2010 and 2020 respectively. Red and yellowish hue in LST variation maps displays higher temperatures, and light green zones indicate medium to lower temperature areas (Figure 7).

According to Table 4, in 2020, out of the total study area of 48.67 km$^2$, 30.49% and 35.40% area were experienced temperatures between 21-< 24$^0$C and 24-< 27$^0$C, respectively. In 2010, 38.52% area was fallen under 24-< 27$^0$C temperature range, and 7.15% area was fallen within the high-temperature range of 34-< 36$^0$C. Moreover, 2020 observed a rapid rise in the temperatures. Nearly 18.75% area was fallen under 27-< 30$^0$C and 4.09% in the range of ≥ 36$^0$C in the study area. Within 20 years (1999-2019) an overall -27.81% LST changes have shown a significant increase in temperature (i.e., 26-31 C) also affected a large area about +33.42% respectively, as an inevitable consequence of rapid urbanization. North-eastern portions of the study area exhibited higher temperatures than other areas, as rapid urbanization was noticeable in this particular direction.

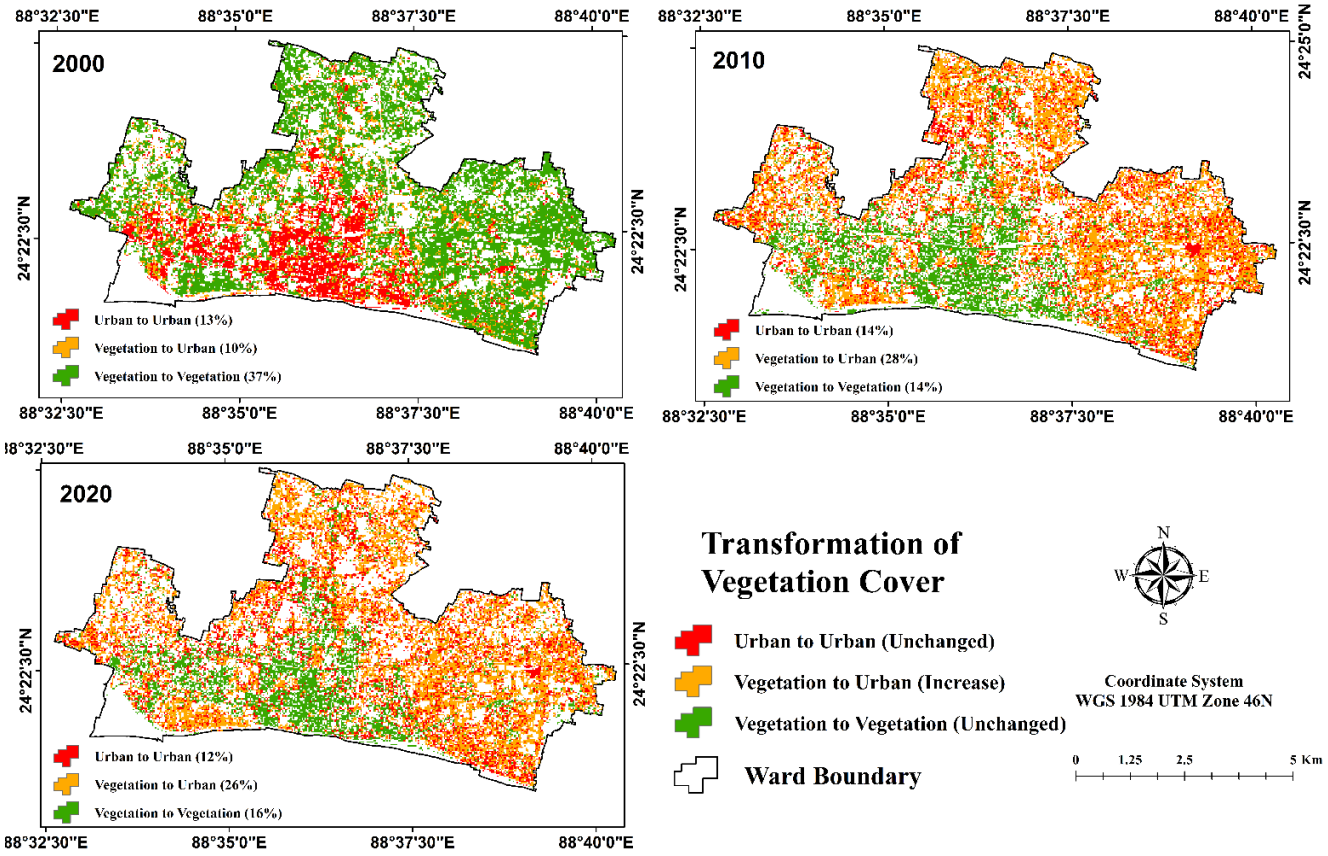


Figure 6. Transformation scenarios of vegetation cover in the study area

Table 4. Areal distribution of surface temperature in different ranges

| Ranges of LST (◦C) | 2000 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % |
| ≤ 20 $^0$C | 6.45 | 13.25 | 0.56 | 1.15 | 0.00 | 0 |
| 21-< 24$^0$C | 14.84 | 30.49 | 9.45 | 19.42 | 0.00 | 0 |
| 24-< 27$^0$C | 17.23 | 35.40 | 18.75 | 38.52 | 0.00 | 0 |
| 27-< 30$^0$C | 10.15 | 20.85 | 11.78 | 24.20 | 18.75 | 38.52 |
| 31-< 33$^0$C | 0 | 0 | 4.65 | 9.55 | 11.25 | 23.11 |
| 34-< 36$^0$C | 0 | 0 | 3.48 | 7.15 | 14.58 | 29.96 |
| ≥ 36$^0$C | 0 | 0 | 0 | | 4.09 | 8.40 |
| Total | 48.67 | 100 | 48.67 | 100 | 48.67 | 100 |

Table 5. Temperature variations influenced by UA and VC in the study area

| Ward Number | UA (%) | | | VC (%) | | | Average LST (°C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2010 | 2020 | 2000 | 2010 | 2020 | 2000 | 2010 | 2020 |
| 1 | 0.6 | 0.7 | 1.1 | 1.4 | 1.2 | 0.9 | 25 | 29 | 34 |
| 2 | 0.2 | 0.4 | 1.5 | 2.9 | 2.5 | 2.0 | 24 | 29 | 34 |
| 3 | 0.6 | 0.8 | 1.0 | 1.0 | 0.5 | 0.5 | 25 | 28 | 34 |
| 4 | 0.3 | 1.0 | 0.6 | 0.9 | 0.7 | 0.7 | 24 | 25 | 32 |
| 5 | 0.1 | 0.1 | 0.8 | 0.6 | 0.4 | 0.4 | 25 | 28 | 34 |
| 6 | 0.5 | 0.6 | 0.6 | 0.5 | 0.4 | 0.4 | 24 | 28 | 34 |
| 7 | 0.9 | 1.1 | 1.2 | 2.2 | 1.5 | 1.1 | 24 | 27 | 33 |
| 8 | 0.7 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 25 | 29 | 34 |
| 9 | 0.5 | 0.6 | 0.6 | 0.2 | 0.1 | 0.1 | 25 | 29 | 30 |
| 10 | 0.6 | 0.8 | 0.8 | 0.6 | 0.4 | 0.4 | 25 | 28 | 31 |
| 11 | 0.1 | 0.4 | 0.8 | 0.1 | 0.0 | 0.1 | 25 | 29 | 33 |
| 12 | 0.8 | 0.7 | 0.7 | 0.1 | 0.0 | 0.1 | 25 | 29 | 32 |
| 13 | 0.6 | 0.6 | 0.6 | 0.3 | 0.2 | 0.2 | 25 | 28 | 33 |
| 14 | 0.5 | 1.4 | 2.0 | 2.7 | 2.3 | 1.5 | 24 | 28 | 34 |
| 15 | 0.8 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 25 | 29 | 30 |
| 16 | 0.8 | 1.2 | 1.5 | 1.7 | 1.2 | 1.0 | 25 | 29 | 34 |
| 17 | 0.2 | 0.9 | 3.5 | 8.4 | 6.9 | 2.7 | 24 | 29 | 36 |
| 18 | 0.4 | 0.8 | 1.0 | 1.4 | 1.5 | 1.2 | 24 | 29 | 33 |
| 19 | 0.7 | 1.0 | 1.3 | 2.7 | 2.3 | 1.8 | 25 | 29 | 33 |
| 20 | 0.5 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 25 | 28 | 31 |
| 21 | 0.3 | 0.4 | 0.3 | 0.4 | 0.3 | 0.3 | 24 | 27 | 34 |
| 22 | 0.5 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 25 | 28 | 34 |
| 23 | 0.5 | 0.6 | 0.5 | 0.3 | 0.1 | 0.2 | 25 | 28 | 34 |
| 24 | 0.2 | 0.3 | 0.4 | 0.2 | 0.1 | 0.1 | 25 | 28 | 34 |
| 25 | 0.6 | 0.6 | 0.6 | 0.5 | 0.3 | 0.3 | 25 | 29 | 34 |
| 26 | 0.2 | 0.3 | 1.6 | 5.8 | 4.4 | 3.1 | 24 | 27 | 35 |
| 27 | 0.1 | 0.3 | 1.7 | 3.5 | 3.0 | 2.3 | 24 | 27 | 33 |
| 28 | 0.8 | 0.9 | 1.0 | 2.3 | 2.0 | 1.5 | 24 | 29 | 33 |
| 29 | 0.1 | 0.4 | 0.9 | 2.1 | 2.1 | 1.3 | 24 | 28 | 32 |
| 30 | 1.7 | 1.9 | 2.7 | 7.9 | 7.5 | 6.4 | 24 | 29 | 32 |
| Total | 15.96 | 21.77 | 31.56 | 51.62 | 42.80 | 32.18 | | | |

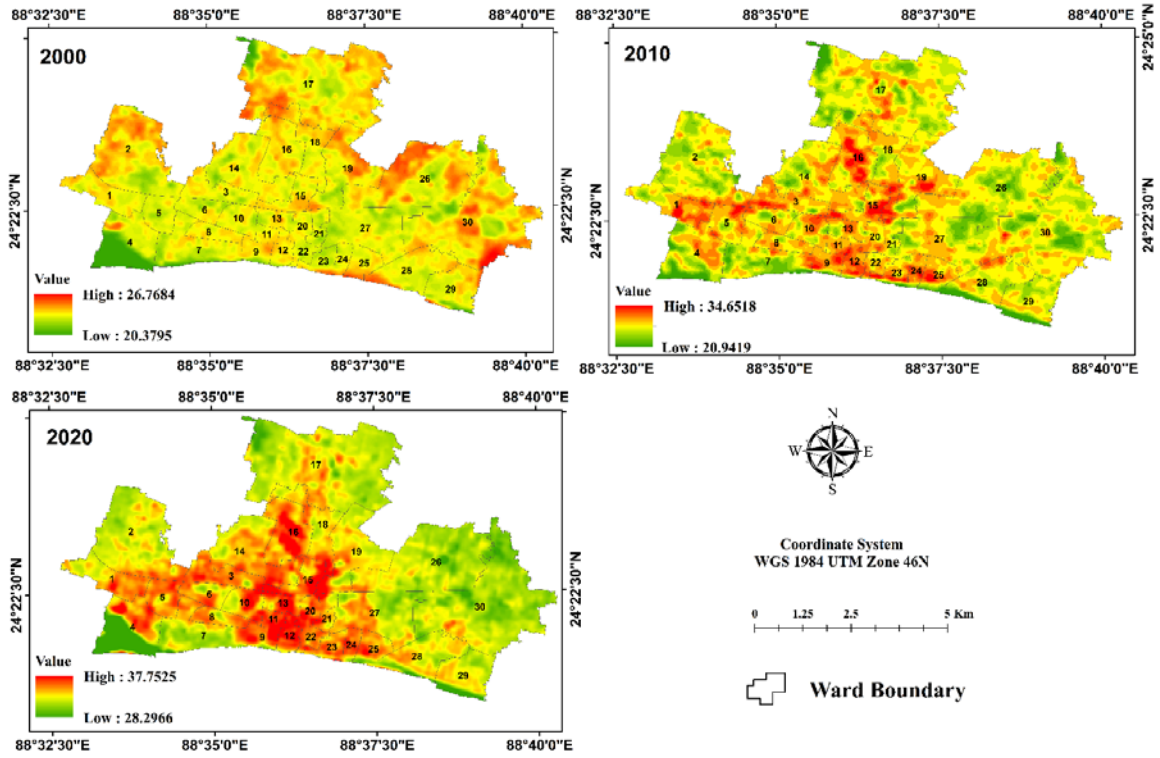


Figure 7. Spatial distribution of Land surface temperature ($^0$C) in the study area

The influence of the increase in UA and decrease in VC on LST in thirty wards of RCC area is demonstrated in Table 5, which describes the variation of average LST in UA and vegetation cover for the year 2000,2010, and 2020 respectively. From Table 5, it is clearly observed that the percentage of VC and UA in each ward significantly influences the average LST increase. For example, in ward 17, UA's rate increased from 0.2% to 3.5%, where VC reduce by 8.4% to 2.7%, respectively, which significantly increase the LST from 24 °C to 36 °C in the last two decades. This scenario is also noticed in all the wards of RCC. Due to less quantity of vegetation, the mean LST is comparatively higher in the urban area. Ignoring the ecosystem-dynamics, the rapid urbanization, and increase in the study area's commercial activities significantly have reduced the vegetation and increased the UHI effect.

## 4. Conclusion

The present study identified the cause of increasing the LST trend, and the reduction of vegetation cover is due to rapid urban expansion in the RCC area. The increase in UA replacing the city's green cover significantly increases the LST of the study area. This increased temperature significantly impacts the habitat, ecosystem, and the urban environment. The maximum positive net change was evident for the UA (+15.55 %), with the maximum negative change in the VC (-19.42%) in the last 20 years. The maximum temperature of the city was increased to 37.75 $^0$C in 2020 from 27.76 $^0$C in 2000. The assessed LST showed that lower recorded temperature zones in 2000 were converted into a higher temperature zone in 2020. The significant increase in LST creating the UHI phenomenon in the RCC area. It is assertive that the impact of the present climate change scenario and the nearby vast dry Barind region also aggravated the trend of LST. To minimize the effects of UHI as a consequence of UA's unplanned development, it is needed to track and predict the change of LULC and the LST pattern of the city. Also, measures and policies should be undertaken to limit unplanned city development and preserve its existing greenery. Also, steps should be adopted for increasing the vegetation in the town by planting trees and minimizing the use of non-evaporating and non-transpiring construction materials with eco-friendly materials.

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# Efficacy of Some Botanical Extracts against Late Blight of Potato in Experimental Field

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## Abstract

Late blight of potato caused by *Phytophthora infestans* (Mont.) De Bary is the most devastating disease of potato. A number of chemical fungicides are being used to manage the disease effectively. However, the use of chemical fungicides is harmful to human and environment. Therefore, eco-friendly fungicides are now widely expected throughout the world. Among the few available alternatives, botanical extracts are the safe alternative to the chemical fungicides because of their eco-friendly nature. Hence, a study was conducted to evaluate the efficacy of ten botanical extracts against late blight of potato in Botanical Pesticide Experimental Field at University of Rajshahi. Crude aqueous extract of leaves of Kalojam (*Syzygium cumini*), Peyara (*Psidium guajava*), Eucalyptus (*Eucalyptus globusus*), Pepe (*Carica papaya*) and Mehidi (*Lawsonia inermis*); fruits of Bohera (*Terminalia bellirica*), Horitoki (*T. chebula*) and Golmorich (*Piper nigrum*); flower buds of Labonga (*Syzygium aromaticum*) andcloves of Rasun (*Allium sativum*) were used at 2.5% (w/v) concentration for evaluation. Among the botanical extracts, leaf of Kalojam (*Syzygium cumini*) was the most effective in terms of percent disease severity (19.68±3.47) compare to the untreated control (62.08±16.77) on 66 days after sowing (DAS). The efficacy of Horitoki (23.89±2.15), Golmorich (23.38±2.79), Labonga (19.69±1.49), Mehidi (25.43±4.10) and Pepe (23.78±1.11) are statistically same to Kalojam on 66 DAS. Mehidi leaf extract showed the highest yield (96.4%) over untreated control. These results suggested that botanical extracts have a great potential to be an alternative of chemical fungicides to control the late blight disease of potato.

**Keywords:** Botanical Extract, Late Blight of Potato, *Phytophthora infestans*, Experimental Field

## 1. Introduction

Potato (*Solanum tuberosum*) is the second most important crop after the paddy in Bangladesh (FAOSTAT, 2019). It is one of the staple foods in Bangladesh and primarily used as a vegetable. Bangladesh is the seventh largest potato producer country in the world (FAOSTAT, 2019). Among the exportable agricultural commodities of Bangladesh, potato is in second position (FAOSTAT, 2019). Potato is the basic raw materials of agro and food industries in Bangladesh (Islam *et al*., 2013). Many appetizing foods made from potatoes such as chips, crackers, crisps and French-fries are high consuming products in Bangladesh. Consequently, its commercial value is increasing rapidly day by day.

On the other hand, potato is the staple food in many countries. It is the cheapest source of carbohydrate and it contains a good amount of vitamin B6 and C as well as some minerals (Singha and Maezawa, 2019; King and Slavin, 2013).

Moreover , a significant amount of potato used in processing industries such as production of alcohol, glucose, dextrin and citric acid for textile and paper industries, inks, dyes, soap and leather as their raw materials (Abouzied and Reddy, 1986). According to Azad *et al.* (2014), potato is used for the production of eco-friendly fuel bio-ethanol.

But potato suffers from a number of diseases and caused a huge loss in terms of production loss around the world. Among the diseases, the late blight caused by *Phytophthora infestans* (Mont.) de Bary is the most devastating disease throughout the world (CIP, 1984). The disease late blight is well known for the historical Irish Potato Famine in 1840s (Chycoski and Punja, 1996; Fry and Goodwin, 1997).

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Potato late blight occurs almost every year in Bangladesh with varying degree of severity (Dey *et al*., 2010). Late blight caused potato yield loss of 50-70% (Khair and Haggag, 2007; Rahman *et al*., 2008). In severe cases late blight destroy the whole potato field with very short time and caused the loss up to 100%.

Currently this disease is managed effectively by using chemical fungicides. However, the use of chemical fungicides is harmful to human and environment. Excessive and injudicious use of these fungicides have been degrading our ecosystem and causing many diseases to human such as neurological, psychological dysfunctions, infertility, cancer and kidney disorders (Laxmishree and Nandit, 2017).

The chemical control of late blight disease is very expensive and causes enormous economic damage amounting to an estimated $5 billion worldwide annually (Axel *et al*., 2012; Haverkort *et al*., 2009; Judelson and Blanco, 2005).

Therefore, an alternative way of controlling late blight of potato is the most desired around the world now a days. Among the several available alternative materials, botanical extracts are the safe alternative to the chemical fungicides because of their eco-friendly nature (Verma and Dubey, 1999). Botanical pesticides have received great attention in recent years as an alternative to chemical pesticides (Wang *et al*., 2004; Bekepe *et al*., 2006) and medicinal plants have shown much potential in controlling plant disease (Cao *et al*., 2001).

Hence, the objective of the present study is to assess the efficacy of some botanical extracts on the late blight disease of potato in experimental field of University of Rajshahi.

## 2. Materials and Methods

### 2.1. Experimental Site and Land Preparation

The experiment was conducted in the Botanical Pesticide Experimental Field of Institute of Environmental Science, University of Rajshahi, Bangladesh during November 2019 to February 2020. The land was firstly ploughed several times with spade, and grass, weeds etc. are removed after each ploughing. A recommended amount of Cow-dung, Triple super Phosphate (TSP), Muriate of Potash (MP) and Urea fertilizers were applied in the experimental field.The field was irrigated two times after sowing.

### 2.2. Collection of Botanicals

Botanicals were collected considering the following properties: odour, anti-fungal activity, phyto-toxicity. Results of previous studies and ethno-botanical knowledge were also kept in mind at the time of plant selection. Most of the selected plant materials were collected from the Rajshahi University campus and some were purchased from local market. The list of plants used in this study is shown in Table-1.

Table 1. Plants Used for the Experiment

| Sl No | Local Name | Scientific Name | Plant Parts Used |
|---|---|---|---|
| 1 | Kalojam | *Syzygium cumini* | Leaves |
| 2 | Peyara | *Psidium guajava* | Leaves |
| 3 | Eucalyptus | *Eucalyptus globusus* | Leaves |
| 4 | Rasun | *Allium sativum* | Clove |
| 5 | Bohera | *Terminalia bellirica* | Fruit |
| 6 | Horitoki | *Terminalia chebula* | Fruit |
| 7 | Golmorich | *Piper nigrum* | Fruit |
| 8 | Labonga | *Syzygium aromaticum* | Flower bud |
| 9 | Mehidi | *Lawsonia inermis* | Leaves |
| 10 | Pepe | *Carica papaya* | Leaves |

### 2.3. Preparation of Botanical Extracts

Collected botanicals were washed through running tap water 2-3 times. After washing the botanicals were dried under shed for 2/3 weeks. Dried materials except garlic grinded with the help of electric grinder to make fine powder (Khair and Haggag, 2007; Majeed *et al*., 2011; Azad *et al*., 2013). 25g of fine powder of each plant materials were dissolved separately in 1000 ml of distilled water in plastic container. In case of garlic, bulbs were cut into small pieces and blended by blender. About 25g of blended garlic dissolved in 1000 ml of distilled water in a plastic container. The containers were kept in room temperature for 72 hours and the mixture was shake gently every day. After 72 hours, the mixture was filtered through three-layer cheesecloth to collect the plant extracts of 2.5% concentration (w/v). The extracts were kept in bottle and preserve in the refrigerator for future use.

### 2.4. Experimental Design and Treatments

The experiment was laid out in completely randomized block design (CRBD) with three replications. The distance between the block was 1m and between the plots was 0.5 m., the unit plot size was 1m × 1m. Twelve treatments were used in this study including two controls (one untreated and one Chemical treated) and ten plant extracts (Table 2.)

Table 2. Description of the Treatments

| Treatment | Concentration |
|---|---|
| T0- Untreated Control (Water) | - |
| T1- Chemical Treated(Fungicide Chlorothalonil) | 1.5 ml/l |
| T2- Kalojam *(Syzygium cumini)* | 2.5% (w/v) |
| T3- Peyara *(Psidium guajava)* | 2.5% (w/v) |
| T4- Eucalyptus *(Eucalyptus globusus)* | 2.5% (w/v) |
| T5- Rasun *(Allium sativum)* | 2.5% (w/v) |
| T6- Bohera *(Terminalia bellirica)* | 2.5% (w/v) |
| T7- Horitoki *(Terminalia chebula)* | 2.5% (w/v) |
| T8- Golmorich *(Piper nigrum)* | 2.5% (w/v) |
| T9- Labonga *(Syzygium aromaticum)* | 2.5% (w/v) |
| T10- Mehidi *(Lawsonia inermis)* | 2.5% (w/v) |
| T11- Pepe *(Carica papaya)* | 2.5% (w/v) |

### 2.5. Botanical Extract Spray

Prepared botanical extracts were sprayed in the field with a hand sprayer to potato leaves twice weekly started at 30 Days after sowing (DAS). Data on disease incidence and severity was collected at 7-day interval on 50, 58, 66 and 73 DAS.

### 2.6. Disease Assessment and Yield Calculation

Disease incidence and severity is expressed in percentage following the formulas bellow (Islam *et al*., 2013)-

$$\text{Disease incidence (\%)} = \frac{\text{No.of diseased plants}}{\text{Total no.of plants observed}} \times 100$$

$$\text{Severity (\%)} = \frac{\text{No. of blighted leaves per plantlet}}{\text{Total no. of leaves per plantlet}} \times 100$$

After harvesting total tuber yield (kg /plot) were calculated by collecting and weighing tubers from each experimental plot and percent yield increase over control was calculate through following formula(Ray *et al*., 2018)-

$$\text{Yield increase (\%)} = \frac{\text{Treatment yield} - \text{Control yield}}{\text{control yield}} \times 100$$

### 2.7. Data Analysis

The collected data were analyzed statistically using analysis of variance (ANOVA) to find out the variations among the treatments and treatments means were compared by DMRT using software SPSS (V20).

## 3. Results

The findings of the present study are shown in Figures 1-4. First data were collected on 50 Days after sowing (DAS). There was no disease incidence in any treatment at this stage. On 58 DAS, all the treatments except untreated control-T0 and Payera-T3 showed significantly better performance compared to untreated control. The highest and lowest disease incidence in percentage observed respectively in-untreated control-T0 (34.72±19.30) and Chlorothalonil-T1 (0±0.00) on 58 DAS (Figure 1). Kalojam-T2 (0±0.00), Mehidi-T10 (0±0.00) and Pepe-T11 (0±0.00) treatments showed equal efficacy to chemically treated treatment Chlorothalonil-T1 on 58 DAS (Figure 1).In terms of percent disease severity, the highest and lowest values observed respectively in-untreated control-T0 (5.34±3.19) and Chlorothalonil-T1 (0±0.00) (Figure 1). The percent disease severity of Kalojam-T2 (0±0.00), Mehidi-T10 (0±0.00) and Pepe-T11 (0±0.00) on 58 DAS were as same as Chlorothalonil-T1 (Figure 1). The rest of the plant extracts showed significantly better performance in terms of percent disease incidence and severity considering untreated control (Figure 1).

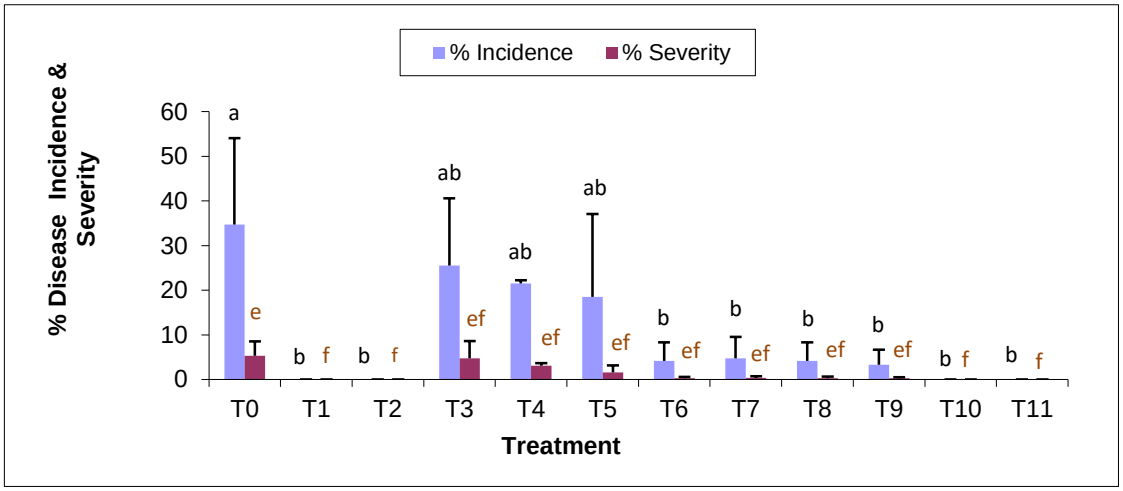


Figure 1. Percent Disease incidence and Severity on 58 DAS

However, disease incidence was 100% in all the treatments except Chlorothalonil-T0 (35.00±7.64) and Kalojam-T2 (88.57±5.95) on 66 DAS (Figure 2). At this stage percent, disease severity was significantly different among the treatments. The highest and lowest percent disease severity observed in untreated control-T0 (62.08±16.77) and Chlorothalonil-T1 (4.46±1.2) treatments, respectively (Figure 2). Among the botanical extracts, Kalojam-T2 and Eucalyptus-T4 showed the lowest (19.68±1.2) and highest (61.61±7.31) percent disease severity, respectively (Figure 2). Disease severity of rest of the botanical extracts Horitoki-T7 (23.89.68±2.1), Golmorich-T8 (23.38±2.79), Labonga-T9 (19.69±1.49), Mehidi-T10 (25.43±4.10) and Pepe-T11 (23.78±1.11) are statistically same to Kalojam (Figure 2). Disease severity of Peyara-T3 (49.94±7.41), Eucalyptus-T4 (61.61±7.31) and Rasun-T5 (52.88±8.71) are statistically same to untreated control on 66 DAS (Figure 2).

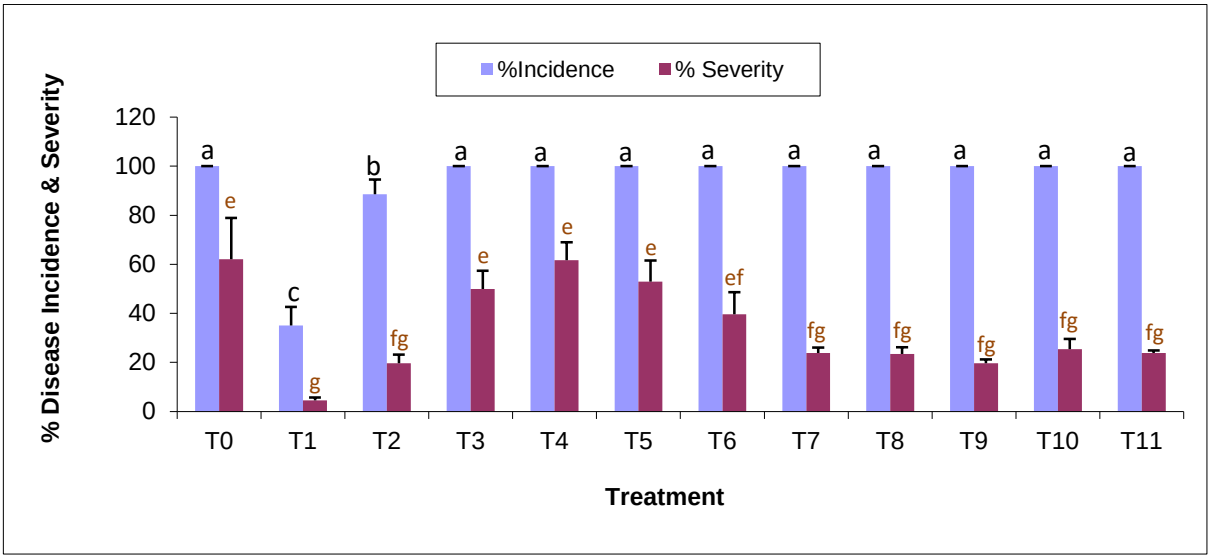


Figure 2. Percent Disease incidence and Severity on 66 DAS

On 73 DAS, percent disease incidence was 100% in all treatments except Chlorothalonil-T1 (57.50±3.82) (Figure 3). Percent disease severity was also 100% in all treatments but Chlorothalonil-T1 (9.78±1.58) and Rasun-T5 (97.46±2.54) on 73 DAS (Figure 3).

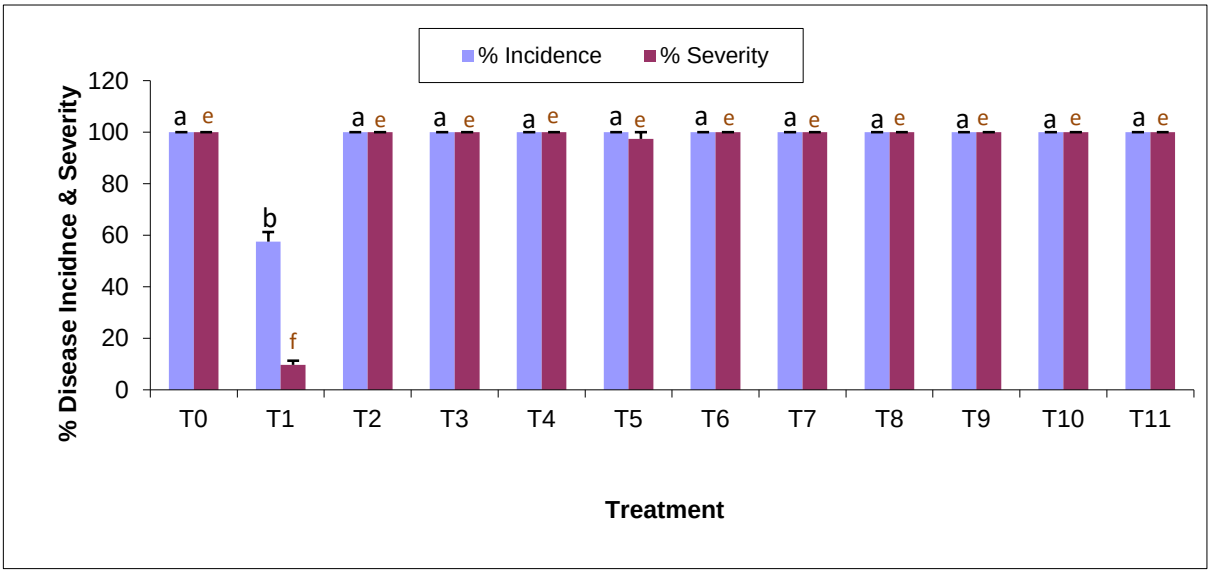


Figure 3. Percent Disease incidence and Severity on 73 DAS

After harvesting, yield per plot was measured and percent yield increase over untreated control was estimated. The highest yield was observed in Chlorothanlonil-T1 (250.98%) treatment (Figure 4). Among the botanical extracts, highest and lowest yield were in Mehidi-T10 (96.42%) and Payera-T3 (12.79%) treatments (Figure 4). Kalojam-T2 (43.16%), Bohera-T6 (59.2%), Horitoki-T7 (59.2%), Golmorich-T8 (60.42%), Lobonga-T9 (71.4) and Pepe-T11 (75.08) were achieved yield increase over untreated control considerably (Figure 4).

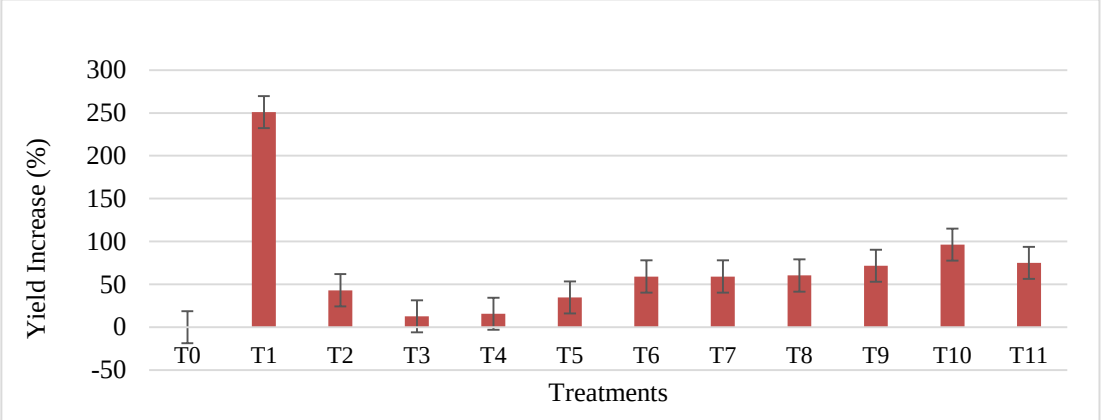


Figure 4. Yield Increased (%) Over Untreated Control

## 4. Discussion

Potato late blight is the major disease that affects the potato production drastically. The disease spreads in the field very rapidly destroy the plants within few days. Consequently, yield deceases extremely. Though, the chemical fungicides are the main tolls to control the late blight of potato till the date, the development of resistance to conventional fungicides by *Phytopthora infestans* and environmental pollution by chemical fungicides is a matter of great concern now. Therefore, the necessity of eco-friendly natural products is increasing day by day. Natural compounds of plants are a very good alternative because of their biodegradability and low toxicity to the environment and human. Efficacy of plant extracts against *Phytophthora infestans* at *in vitro* and under field conditions assessed by many researchers such as Cao *et al*.,2001; Khair and Haggag, 2007; Majeed *et al*., 2011; Subhani *et al*., 2014; Deshi *et al*., 2015 and Amienyo *et al*., 2017 for last few decades.

In the present study, it is found that reduction of disease incidence and severity by all treatments were superior over control up to 58 DAS. On 66 DAS and onwards up to 73 DAS, disease incidence of all treatments except Chlorothalonil-T1 and Kalojam –T2 were 100. On 73 DAS and onwards disease severity was 100% by all treatments except Chlorothalonil-T1 and Rasun-T5.

Khair and Haggag, 2007 found that 2.5% aqueous extract of garlic (Rasun) reduce the late blight severity by 54.2% that agrees with findings of 66 DAS of the present study. Findings of Subhani *et al*., 2014 and Amienyo *et al.,* 2017 showed that Garlic extract reduce the intensity by 44.4% and 47%, respectively, which agrees the present findings. Cao *et al*., 2004 found that Horitoki (*Terminalia chebula)* reduce infection on detached leaves up to 99.4%. This also support our findings on Horitoki under field conditions. Khair and Haggag, 2007 and Subhani *et al*., 2014 found that Eucalyptus reduce the disease severity to 34.3% and 28.35% under field conditions, which is almost similar to the findings of present study.

## 5. Conclusions

The finding of the present study is a step towards the exploration of botanical fungicides as an eco-friendly alternative to conventional fungicides. In the present study, out of ten botanicals, six extracts such as Kalojam (*Syzygium cumini*), Horitoki (*Terminalia chebula*), Golmorich (*Piper nigrum*), Labonga (*Syzygium aromaticum*), Mehidi (*Lawsonia inermis*) and Pepe (*Carica papaya*) showed promising efficacy on controlling the severity of late blight of potato under field conditions. However, more studies are needed for isolation and characterization of the active ingredients of these botanical extracts to confirm the findings.

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# Germination and Seedling Growth Performance of *Benincasa hispida* (Thunb.) Cogn. in Arsenic Solution Cultures under Phosphorus Amendment

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## Abstract

Arsenic (As) is a toxic metalloid widely distributed in the environment posing a serious threat to human health. Based on past studies, it was postulated that enriching the soil with phosphorus (P) is an option to offset the negative effects of As on plant growth. However, attempts towards finding the precise role of P are limited. This study, therefore, aimed to determine the efficacy of P in balancing the negative effects of As on *Benincasa hispida* as measured in terms of seed germination, seedling growth and biomass production of seedling. Seeds of *B. hispida* were treated with different concentrations (2 ppm, 5 ppm and 10 ppm) of As, with or without addition of P (10 ppm). As exposure hindered germination rate, seedling growth and biomass production of seedling to different magnitudes depending on the concentrations. Addition of P in As solution cultures improved the seed and seedling performance significantly. Germination were 91% in 2 ppm As+10 ppm P, 85% in ppm As+10 ppm P and 74% in 10 ppm As+10 ppm P compared to 89% in 2 ppm As, 79% in 5 ppm As and 67% in 10 ppm As. In treatments T1 2 ppm As, T3 5 ppm As and 10 ppm As, seedling dry biomasses were 24 mg, 12 mg and 10 mg respectively, which were enhanced to 27 mg, 19 mg and 15 mg respectively in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. Similar trend was also recorded for plumule growth, seedling fresh biomass production, seedling vigor, sturdiness etc. This study, therefore, recommended the application of P to reduce the negative effects of As on *B. hispida* in As solution culture under laboratory condition and maintains that the results may hold good in the field condition as well.

**Keywords:** Arsenic; *Benincasa hispida*; Germination; Phosphorus; Seedling vigor; Sturdiness.

## 1. Introduction

Native to South Asia and Southeast Asia including Bangladesh - *Benincasa hispida* (Thunb.) Cogn., the wax gourd, also known as winter melon, is widely grown throughout Asia, including Java and Japan where it is thought to have originated (Bimakr *et al.,* 2016). It is belong to the horticulturally diverse gourd family Cucurbitaceae and only member of the genus *Benincasa*. Wax gourd is a vine grown for its very large fruit, eaten as a vegetable when mature. The fruit is fuzzy when young and has thick white flesh that is sweet. By maturity, the fruit loses its hairs and develops a waxy coating and providing a long shelf life (Rayees *et al.,* 2013). It is grown in well drained loam and sandy soils, in warm mild climates, but will not tolerate frosts. The crops are grown in riverbeds or furrows, and needs constant irrigation during the growing season (Rayees *et al.,* 2013; Bimakr *et al.,* 2016).

In Bangladesh, elevated concentration of arsenic (As) in the surface soil of agricultural field and in plant tissue were reported since As contaminated groundwater has been used for irrigation (Meharg and Rahman, 2003). Areas under wax gourd cultivation in Bangladesh are prone to the risk. Being a toxic element, As poses serious threats to environment and human health (Leimu and Fischer, 2008; Singh *et al.,* 2015; Babst-Kostecka *et al.,* 2016; Guevara-Garcia *et al.,* 2017; Khan *et al.,* 2018). When crops are grown in As-contaminated soil or irrigated with As-contaminated water, As gets accumulated in the seeds or grain which is becoming an increasingly important problem in many parts of the world (Sanal *et al.,* 2014) as it poses significant risk to animal and human health through soil-crop transfer (Fitz and Wenzel, 2002; Sultana *et al.,* 2015). At high level of As concentrations, biomass production and yields of a variety of crops shrink significantly (Carbonell-Barrachina *et al.,* 1997; Chaturvedi, 2006). Especially, plants with highly water-retentive fruits, such as wax gourd, accumulates As in elevated concentrations in their fruit (Mishra *et al.,* 2014). Melons including wax gourd, however, is naturally efficient in preventing As accumulation in the fruit (Hettick, 2016).

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On the other hand, Phosphorus (P) - an essential plant nutrient that regulates cellular energy transfer, respiration, and photosynthesis (Marschner, 1995) - is a chemical analogue of As (Raghothama, 1999; Khan *et al.*, 2013; Meharg *et al.*, 2014). Therefore, in plant uptake of nutrients, P contests As due to their chemical similarity (Meharg and Macnair, 1992a). Consequently, the changes in P transport mechanisms regulates As uptake (Adriano, 2001) and evidently, the use of P as a fertilizer modifies the sorption/desorption of As in soil environment (Peryea, 1998). Most of the previous studies on As and P interactions in hydroponic and soil cropping yielded mixed results and both increase and decrease in As uptake were reported under P addition (Meharg and Macnair, 1992b; Lee *et al.*, 2003). However, there is lack of studies aimed to find out the precise role that P plays in buffering the negative effects of As specially during seed germination and seedling growth. Therefore, this study aimed to check the efficacy of P in reducing the negative effects of As during seed germination and initial seedling growth in terms of biomass production of *B. hispida*.

## 2. Materials and Methods

### 2.1. Study Site and Period of Study

The experiment was carried out at the environmental lab of the Institute of Forestry and Environmental Sciences ($91^0$50´E and $22^0$30´N), University of Chittagong (IFESCU), Bangladesh. It was conducted between January and May 2017 as the seeds of *B. hispida* are mostly available in this period in Bangladesh.

### 2.2. Collection of Seeds

Healthy and disease-free seeds were extracted from ripen *B. hispida* fruits. Seeds were dried in the sunlight before storage in airtight polybags which were then kept at refrigerator until use. Seeds of uniform sizes and colors were selected to avoid non-treatment variations (Bonner, 1987)**.**

### 2.3. Preparation of Hoagland's and other Solutions

Hoagland's nutrient solution was prepared as stated in Hoagland and Arnon (1950). The solution comprised of $KNO_3$, 0.5 g $L^{-1}$; $Ca(NO_3)$. $4H_2O$, 1.2 g $L^{-1}$; $MgSO_4$. $7H_2O$, 0.5 g $L^{-1}$; $H_3BO_3$, 2.8 mg $L^{-1}$; $ZnSO_4$, 0.2 mg $L^{-1}$; $CuSO_4$, 0.05 mg $L^{-1}$; $NH_4NO_3$, 0.08 mg $L^{-1}$; $MnCl_2$. $4H_2O$, 1.8 mg $L^{-1}$; $Na_2MoO_4$. $2H_2O$, 0.12 mg $L^{-1}$; FeEDTA, 0.02 g $L^{-1}$; in a volume of 1 L. P was added as 0.07 g $L^{-1}$ of $KH_2PO_4$ for P treatment and As was added as 0.042 g $L^{-1}$ of $Na_2HAsO_4$. $7H_2O$ for As treatment. The stock solutions were diluted as required for various treatments. The pH (6.0) of the stock and diluted solutions was adjusted with 1M HCl and 1M NaOH for all the treatments. Hoagland's solution without P was common for all the treatments including control.

### 2.4. Experimental Design and Treatment Combinations

Petri dishes were sterilized by keeping overnight at 200 $^0$C in convection oven. In each petri dish, three layers of moist sterilized filter paper were placed. A Randomized Complete Block Design (RCBD) with 7 treatments with 5 replications was adopted for this experiment. A total of 35 petri dishes were needed for this experiment. The treatment combinations used in the experiment were:

**T0 = Control** (Hoagland's solution without P)

**T1 = 2 ppm As** (Hoagland's solution without P + 2 ppm As)

**T2 = 2 ppm As + 10 ppm P** (Hoagland's solution with 10 ppm P + 2 ppm As)

**T3 = 5 ppm As** (Hoagland's solution without P + 5 ppm As)

**T4 = 5 ppm As + 10 ppm P** (Hoagland's solution with 10 ppm P + 5 ppm As)

**T5 = 10 ppm As** (Hoagland's solution without P + 10 ppm As)

**T6 = 10 ppm As + 10 ppm P** (Hoagland's solution with 10 ppm P + 10 ppm As)

Seeds were soaked in 0.05% Mercuric chloride solution for 1 minute for sterilization followed by washing with distilled water and drying before sowing them on petri dishes. In each petri dish, 20 seeds of *B. hispida* were sown and a total of seven hundred seeds were subjected to 7 different treatments. After sowing the seeds, all the petri dishes were placed at ambient temperature and exposed to natural daylight in the laboratory. The filter

papers of the petri dishes were kept constantly wet at the same level by applying the specific solution of As and P to the specific petri dishes.

### 2.5. Data Recording

Germination was recorded daily from the date of seed sowing to the last date of germination. The seedlings were allowed to grow for 15 days from the time of seed sowing. After 15 days, 10 representative seedlings from each treatment were selected to measure growth parameters. The recorded parameters were plumule and radical lengths, collar diameter, fresh weights of plumule and radicle, dry weights of plumule and radicle, number of lateral roots. Plumule and radicle were oven dried at 75 $^0$C for 48 hr to record dry weights. Total height from the collar area to seedling tip of each seedling in each petridish was measured to the nearest 0.1 cm by using a ruler. Vigor index was calculated according to Abdul-Baki and Anderson (1973) as germination percent × mean total (plumule and radical) length. Volume index was obtained by multiplying plumule length (cm) with the square of collar diameter (mm)$^2$ of the seedlings (Hatchell, 1985). Sturdiness was obtained by dividing plumule length (cm) with collar diameter (cm) of the seedling. The quality index (QI), as developed by Dickson *et al.,* (1960) to quantify seedling morphological quality was calculated as follows:

$$QI = T_{dw} / \left( \frac{H}{D_c} + \frac{P_{dw}}{R_{dw}} \right)$$

where, QI = Quality index, $T_{dw}$= Total dry weight (g), H = Plumule height (cm), $D_c$= Collar diameter (mm), $P_{dw}$= Plumule dry weight (g), $R_{dw}$= Radicle dry weight (g).

### 2.6. Statistical Analysis

SPSS ver. 23 was used for statistical analysis of data related to seed germination and seedling growth attributes. The statistical significance of the differences among the mean values was ascertained by Duncan's multiple range test (DMRT). Different letters in the table indicates significant differences.

## 3. Results

### 3.1. Germination Percentage

Germination were 91% in 2 ppm As+10 ppm P, 85% in 5 ppm As+10 ppm P and 74% in 10 ppm As+10 ppm P compared to 89% in 2 ppm As, 79% in 5 ppm As and 67% in 10 ppm As. The result indicated enhancement of germination percentage with the addition of P in corresponding As solution cultures with decreasing As concentrations (Table 1).

Table 1. Seed germination, seedling survival, plumule and radical growth, collar diameter and number of lateral root of *Benincasa hispida* in arsenic (As) solution cultures under phosphorus (P) amentment

| Treatment | Seed germination (%) | Seedling survival (%) | Length (cm) | | Total length (cm) | Collar diameter (mm) | Lateral root (Number) | Increased/decreased (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Plumule | Radicle | | | | Germination | Plumule-radicle ratio | Total length |
| **T0** | 93$^a$ | 97$^a$ | 7.7$^a$ | 6.5$^a$ | 14.2$^a$ | 2.2$^a$ | 23$^a$ | 0.0 | 0.0 | 0.0 |
| **T1** | 89$^a$ | 92$^a$ | 6.8$^a$ | 6.1$^a$ | 12.9$^a$ | 1.9$^a$ | 19$^a$ | -4.3 | -5.9 | -9.2 |
| **T2** | 91$^a$ | 94$^a$ | 7.4$^a$ | 5.8$^a$ | 13.2$^a$ | 2.0$^a$ | 22$^a$ | -2.2 | +7.7 | -7.0 |
| **T3** | 79$^b$ | 75$^{bc}$ | 4.7$^c$ | 3.5$^b$ | 8.2$^b$ | 1.8$^a$ | 12$^b$ | -15.1 | +13.4 | -42.3 |
| **T4** | 85$^{ab}$ | 83$^b$ | 5.8$^b$ | 3.4$^b$ | 9.2$^b$ | 1.7$^b$ | 14$^b$ | -8.6 | +44.0 | -35.2 |
| **T5** | 67$^c$ | 58$^d$ | 3.3$^d$ | 2.1$^c$ | 5.4$^d$ | 1.6$^b$ | 08$^c$ | -28.0 | +32.7 | -62.0 |
| **T6** | 74$^b$ | 71$^c$ | 5.1$^b$ | 2.5$^c$ | 7.6$^c$ | 1.7$^b$ | 11$^b$ | -20.4 | +72.2 | -46.5 |
| ***P* value** | 0.003 | <0.001 | <0.001 | <0.001 | 0.005 | <0.001 | 0.016 | -- | -- | -- |
| ***F* value** | 10.32 | 25.91 | 32.41 | 26.12 | 9.25 | 38.51 | 6.34 | -- | -- | -- |

Note: a-d = Mean values with different lowercase superscripts in a column indicates significant difference, according to Duncan's Multiple Range Test

(DMRT). T0= Control, T1=2ppm As, T2= 2ppm As+10ppm P, T3= 5ppm As, T4= 5ppm As+10ppm, P, T5= 10ppm As, T6= 10ppm As+10ppm P.

### 3.2. Mean Daily and Cumulative Germination Percentages

The highest mean daily germination was 47% in 5 ppm As+10 ppm P on the 2nd day followed by 37% in 2 ppm As on the 2nd day (Figure 1). The highest cumulative germination percent from 2nd day up to the 3rd day was in 5 ppm As+10 ppm P while, from 4th day up to the 5th day, it was highest in 2 ppm As and from 6th day up to last day of germination (9th day), it was highest in control. The lowest cumulative germination was recorded in 10 ppm As (Figure 2). The finding indicated the negative impact of increasing As concentration on the progress of germination while addition of P into the solution showed augmenting effect.

### 3.3. Growth Performance

Plumule lengths were 6.8 cm, 4.7 cm and 3.3 cm, respectively in treatments 2 ppm As, 5 ppm As and 10 ppm As, while they were 7.4 cm, 5.8 cm and 5.1 cm in respective treatments 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. The outcome clearly demonstrated an increase in plumule length with the addition of P in decreasing concentrations of As in corresponding As solution cultures (Table 1). Significantly ($P$<0.001) high (6.5 cm) and low (2.1 cm) radical growths were recorded respectively in control and in 10 ppm As. In treatments 2 ppm As, 5 ppm As and 10 ppm As, the number of lateral roots were 19, 12 and 8 respectively, while they were 22, 14 and 11 respectively in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. Similar trend was also observed for collar diameter (Table 1). Plumule-radicle ratio was increased with the increase of the concentration of As and the increment was further enhanced with the addition of P in the As solution (Figure 3).

### 3.4. Biomass Production

Seedling dry biomasses were 24 mg, 12 mg and 10 mg respectively, in treatments 2 ppm As, 5 ppm As and 10 ppm As. They were 27 mg, 19 mg and 15 mg respectively in T2 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. Similar trend was evident for fresh biomasses of seedling (Table 2).

Table 2. Fresh and dry biomasses, vigor index and volume index of *Benincasa hispida* in arsenic (As) solution cultures under phosphorus (P) amendment

| Treatment | Seedling biomass (mg) | | Index | | Increased/decreased (%) | | |
|---|---|---|---|---|---|---|---|
| | Fresh | Dry | Vigor | Volume | Dry biomass | Vigor index | Volume index |
| **T0** | $214^{a}$ | $29^{a}$ | $1321^{a}$ | $37.3^{a}$ | 00.0 | 00.0 | 00.0 |
| **T1** | $155^{b}$ | $24^{a}$ | $1148^{a}$ | $24.5^{b}$ | -17.2 | -13.1 | -34.3 |
| **T2** | $188^{a}$ | $27^{a}$ | $1201^{a}$ | $29.6^{a}$ | -6.9 | -9.1 | -20.6 |
| **T3** | $86^{c}$ | $12^{bc}$ | $648^{b}$ | $15.2^{c}$ | -58.6 | -50.9 | -59.2 |
| **T4** | $134^{b}$ | $19^{b}$ | $782^{b}$ | $16.8^{c}$ | -34.5 | -40.8 | -55.0 |
| **T5** | $64^{d}$ | $10^{c}$ | $362^{c}$ | $8.4^{d}$ | -65.5 | -72.6 | -77.5 |
| **T6** | $102^{bc}$ | $15^{b}$ | $562^{b}$ | $14.7^{c}$ | -48.3 | -57.5 | -60.6 |
| ***P* value** | <0.001 | <0.001 | 0.016 | <0.001 | -- | -- | -- |
| ***F* value** | 78.3 | 91.87 | 6.34 | 19.16 | -- | -- | -- |

Note: a-d = Mean values with different lowercase superscripts in a column indicates significant difference, according to Duncan's Multiple Range Test (DMRT).

### 3.5. Vigor, Volume and Quality Indices and Sturdiness

Vigor index were 1148 in 2 ppm As, 648 in 5 ppm As and 362 in 10 ppm As, while they were 1201, 782 and 562 respectively in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P as shown in table 2 and the differences were significant at $P$=0.016. In treatments 2 ppm As, 5 ppm As and 10 ppm As, volume index were 24.5, 15.2 and 8.4 respectively compared to 29.6, 16.8 and 14.7 respectively in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. Quality index values, as shown in figure 4, were 0.0054 in 2 ppm As, 0.0042 in 5 ppm As and 0.0024 in 10 ppm As in contrast with significantly ($P$=0.004) higher 0.0057, 0.0050 and 0.0036 respectively in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P. The highest quality index value was 0.0059 for control. In treatments 2 ppm As, 5 ppm As and 10 ppm As, sturdiness were 32.3, 26.1 and 20.6 respectively compared to significantly higher ($P$<0.001) respective values 37.0, 34.1, 30.0 in 2 ppm As+10 ppm P, 5 ppm As+10 ppm P and 10 ppm As+10 ppm P (Figure 5). All of these observations followed the general trend that higher concentration of As was unfavorable while the addition of P into As solutions improved the seedling performance.

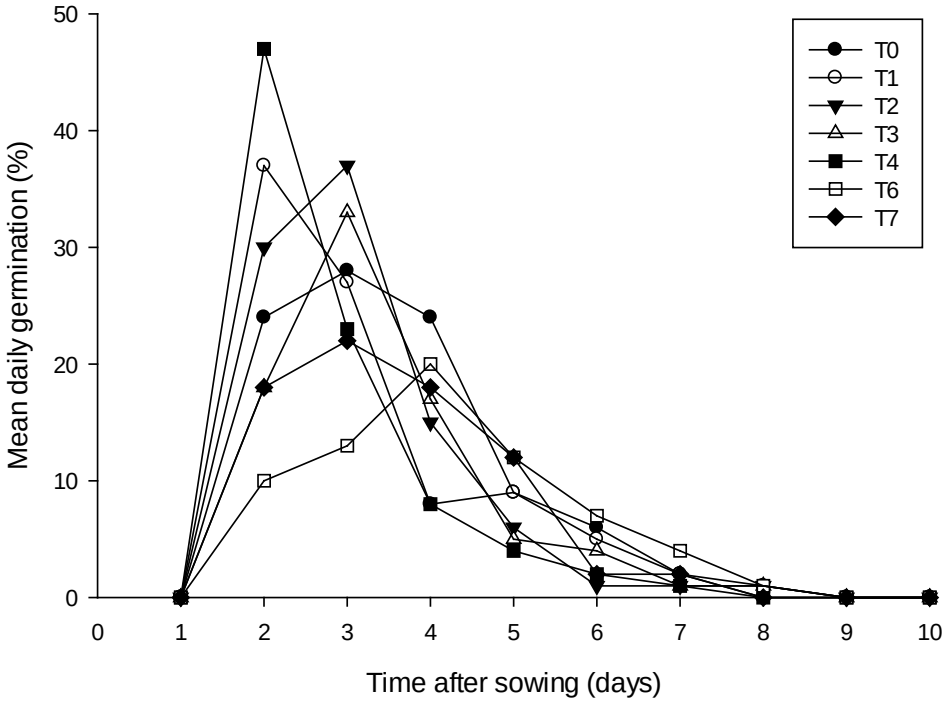


Figure 1. Mean daily germination (%) of *Benincasa hispida* seeds in arsenic (As) solution cultures under phosphorus (P) amendment. T0= Control, T1=2ppm As, T2= 2ppm As+10ppm P, T3= 5ppm As, T4= 5ppm As+10ppm, P, T5= 10ppm As, T6= 10ppm As+10ppm P.

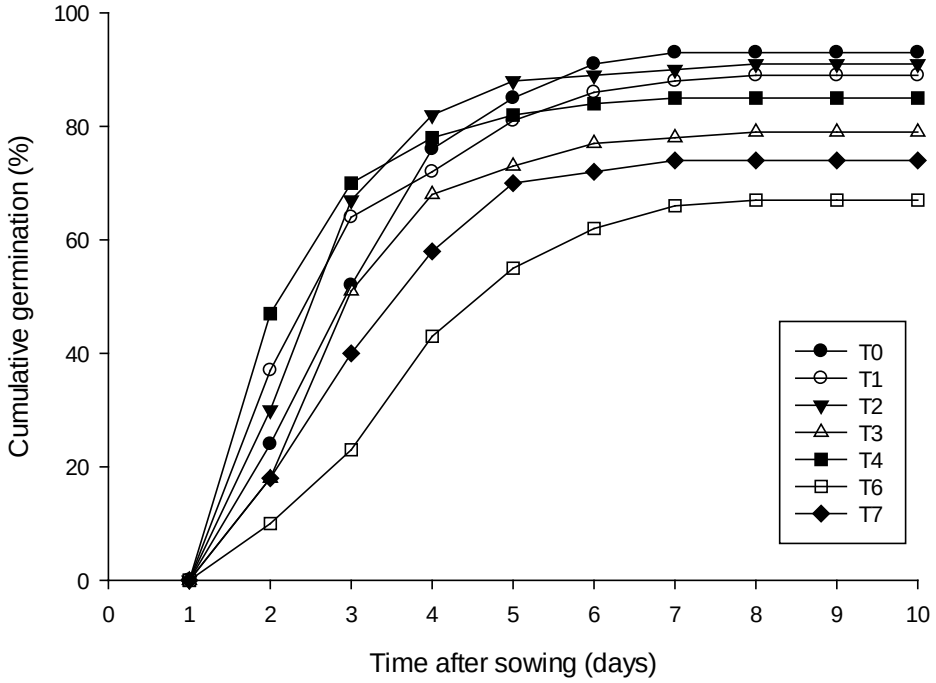


Figure 2. Cumulative germination (%) of *Benincasa hispida* seeds in arsenic (As) solution cultures under phosphorus (P) amendment.

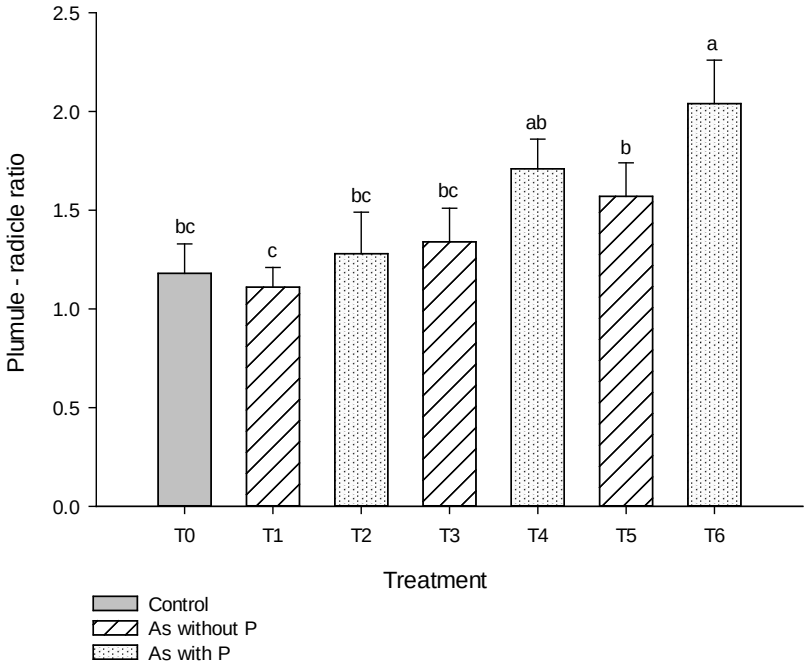


Figure 3. Plumule - radicle rato of *Benincasa hispida* in arsenic (As) solution cultures under phosphorus (P) amendment.

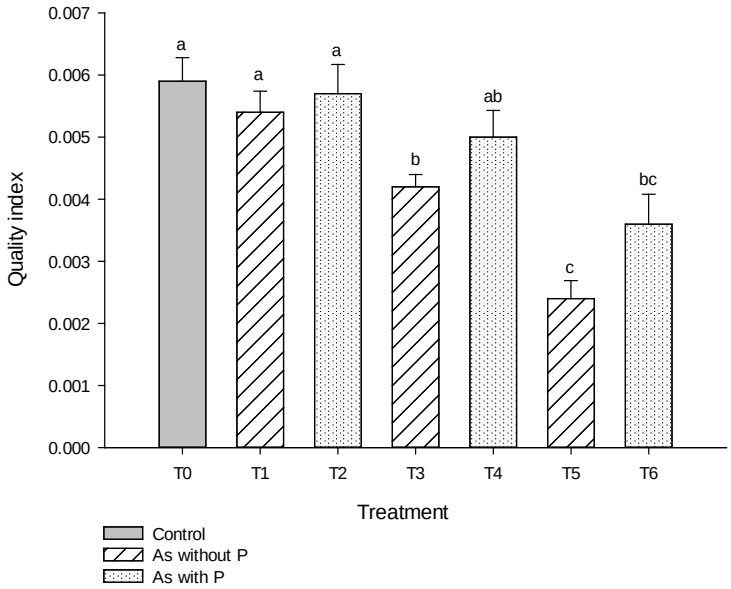


Figure 4. Quality index of *Benincasa hispida* in arsenic (As) solution cultures under phosphorus (P) amendment.

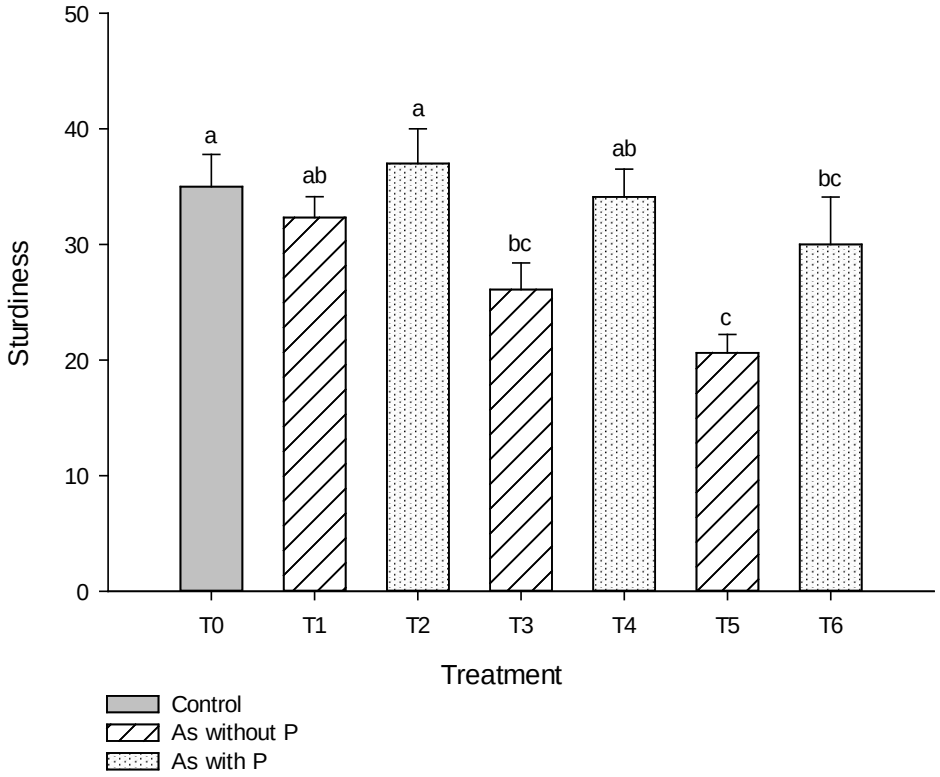


Figure 5. Sturdiness of *Benincasa hispida* in arsenic (As) solution cultures under phosphorus (P) amendment.

## 4. Discussion

Accumulation of As mainly occurs in the root system in plants, and in the aboveground organs to a lesser degree. Such accumulation reduces crop productivity through physiological changes in plants (Stoeva *et al.,* 2005; Leimu and Fischer, 2008; Khan *et al.,* 2013; Meharg *et al.,* 2014; Khan *et al.,* 2018). Arsenic interrupts the biochemical function of cells and severely impedes different plant metabolic processes including transpiration, respiration, photosynthesis etc., by reacting with proteins and enzymes which culminates in stunted plant growth (Meharg and Hartley-Whitaker, 2002). Plants must take up sufficient amount of P to balance excessive As for the alleviation of As toxicity. The plants react to As exposure by increasing P accumulation (Burlo *et al.,* 1999; Leimu and Fischer, 2008; Khan *et al.,* 2013).

This study found that, As solution reduces the rate of seed germination, seedling growth and biomass production of seedling of *B. hispida* to varying magnitudes based on the level of As concentrations (2ppm, 5 ppm and 10 ppm). However, addition of P (10 ppm) in As solution cultures (2 ppm, 5 ppm and 10 ppm respectively) off setted the harms significantly in comparison to corresponding P-free As solutions. Lou-Hing *et al.*, (2011) also reported that phosphate protects a rice variety- Bala from As toxicity at a lower concentration (13.3 µM) of As in the solution culture. Since As is a phosphate analogue, phosphate transporters transports As which results in competition between P and As for uptake at the level of membrane transport. Accordingly, P is expected to reduce arsenate influx resulting ultimately into an observed increase in arsenate tolerance under phosphate addition (Ullrich-Eberius *et al.,* 1989; Meharg and Macnair, 1990; Khan *et al.,* 2013; Meharg *et al.,* 2014). Studies, especially in hydroponic environments, have demonstrated that non-resistant plants can be made more resistant to arsenate by raising their P status, as the P is taken more effectively compared to arsenate (Meharg and Macnair, 1992b; Lee *et al.,* 2003; Khan *et al.,* 2013). Increasing cytoplasmic phosphate concentration in wheat also demonstrated the role of phosphate against As toxicity (Meharg, 1994). Higher phosphate concentration plays an important role to down-regulation of the arsenate-phosphate plasma membrane transporter and competes with arsenate for biochemical processes where arsenate substitutes for phosphate (Pigna *et al.,* 2009).

## 5. Conclusion

Presence of As reduced the rate of seed germination, seedling growth and biomass production of *B. hispida.* The addition of P in As solution enhanced the performance of *B. hispida* seeds and seedlings. Hence, application of P can be recommended to reduce the negative effects of As on *B. hispida* growth in the laboratory. This similar approach might also be applicable in the field.

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# Assessing the Potentiality of Five Medicinal Plant Extracts to Control the Thrips (*Scirtothrips bispinosus*) of Tea Garden

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## Abstract

Several pests including 1034 species of arthropods and 82 species of nematodes are the major pests which attack the tea plants globally. Among them, 25 species of insects, 4 species of mites and 10 species of nematodes are recorded from Bangladesh. In the advent for the search of potentiality of different medicinally important plants to control thrips of tea leaves, this experiment was carried out at lab as well as tea field. Five medicinal plants *viz. Monochoria vaginalis, Cassia alata, Nerium odoratum, Annona squamosa* and *Mikania cordata* were used with 50% alcohol extraction in different concentration. Mortality time was counted to quantify the efficiency and potentiality of different plants extracts on thrips named *Scirtothrips bispinosus*in the field.The result of one-way ANOVA and post hoc analysis reveals that *Monochoria vaginalis* and *Nerium odoratum* have the most potential to control the attack of *Scirtothrips bispinosus* based on time and extract concentration. The Omnibus test reveals that the different concentrations of plant extract have significant effect on the number of mortalities of thrips. The number of deaths of the thrips was found as 5 times higher for 5% concentration than 1% concentration of extract. The death of thrips potentiality was found to decreased with the decreasing of concentrations.

**Keywords:** Extracts; Medicinal Plant; Tea; Thrips; Potentiality

## 1. Introduction

In the recent decades, search for pest control products from plants continues to grow, but not always with clear outcomes and benefits (Isman and Grieneisen, 2013). However, there are many plant species with known pesticidal properties where many is already known about their chemistry and efficacy under laboratory conditions (Stevenson *et al.*, 2017). Isman (2017) has argued that increasing use of natural pesticides needs research directed at the practical application of such products under complex agro-ecological conditions, particularly understanding how different pesticidal plant species perform when applied to different crops under different growing conditions. Using unprocessed plant extracts for pest control has several advantages in terms of preventing the development of insecticide resistance due to the usual presence of several bio-active compounds, their low persistence in the environment and their generally low cost of use, particularly for smallholder farmers with limited income (Angioni *et al*, 2005; Caboni *et al*, 2006; Isman 2008). Consumers and policy makers are demanding reduced synthetic inputs in food production, and practices that support agro-ecological intensification and pesticidal plant products may be well suited to this vision (Grzywacz *et al.*, 2014; Sola *et al.*, 2014; Pavela 2016).

Tea is one of the most consumed non-alcoholic as well as medicinal beverages in the world. At present, more than 58 countries around the world produce tea, while Bangladesh is now ranked 10$^{th}$ position amongst the tea growing countries. But tea plants are subjected to the attack of insects, mites and nematode pests (Paul *et al*, 2017). Mamun *et al.*, (2016) reported that about 15% of tea production could be lost per year by various pests particularly insects, mites and nematodes if adequate control measures are not taken in Bangladesh. So far, 25 insect, four mites and 10 nematode species of tea related species had been recorded in Bangladesh *(*Sana 1989; Ahmed, 2005*).* Due to climate change, pest infestation is increasing as well as pest status is changing (Noori *et al.*, 2016). Besides, deforestation is resulting in the migration of forest pest to tea ecosystem (Antony *et al.*, 2012). Natural bio-control agents play an important role to regulate the pest population in tea ecosystem. Existence of more than one hundred species of indigenous natural bio-control agents of tea pests including predators, parasites and parasitoids were recorded from the tea ecosystem (Borthakur *et al.*, 2010).

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The increasing awareness of negative effects of synthetic pesticide on human and animal health and the agro-ecosystem, research efforts on alternative and more environmentally friendly methods of controlling pests and diseases have proliferated (Zhou *et al.*, 2019, Hagstrum and Athanassiou, 2019). Usage of extract from plants containing natural anti-pest compounds for pest control is considered to be one of the desirable methods for plant protection in agriculture (Kim *et al.*, 2003). In recent past, several plant species had been screened for anti-pest activity and extracts/purified compounds from these plants were found to have a broad spectrum of anti-pest activity (Grayer and Harborne, 1994). Considering the above evidences, the present study was undertaken to find out most potential plant extract against *Scirtothrips bispinosus* (tea leaf's thrips). It is expected that the output of the study could be helpful to provide information regarding plant-insect interaction and to predict suitable techniques for controlling tea pests naturally.

## 2. Materials and Methods

Tea leaves were used as the basic elements for this study which were infected by thrips. These infected leaves were collected from Habibnagar Tea Estate and Khan Tea Estate in Sylhet, and Baraoora Tea Estate in Moulvibazar district of Bangladesh. Climate of this region is considered sub-tropical monsoon with three distinct seasons: pre-monsoon season (February to April), monsoon season (May to August) and winter season (September to January). It was observed that about 1400 mm of annual rainfall is a critical limit and the monthly mean temperature is between 18.33°C to 29.44°C seem unfavorable for tea production in Bangladesh (Ahmed 2005 and Sana, 1989).

In this study, five plants extracts were used. The plants were *Monochoria vaginalis* (Bhat Meteka/ Panee Kachu), *Cassia alata* (Dadmurdan), *Nerium odoratum* (Karabi/Raktakarabi), *Annona squamosa* (Ata/Ata Phol) and *Mikania cordata* (Refusilata/Jarmanilata). The leaf of five plants were collected and dried in the sun. Fully dried leaf is grinded into fine powder and then placed into 50% alcohol as solvent. The solvent to sample ratio were 4:1. The conical were screw caped and placed in a shaker at room temperature for 24 h at 100 rpm. After 24 h, the extracts were filtered using a muslin cloth and then re-filtered using Whatman filter paper No.1. The extracts were labeled accordingly and preserved in the refrigerator at 4°C, till further work. The collection of thrips affected plants were repeated for three times. For each replication, four densities i.e., 1%, 5%, 10% and 15% concentration of extract were used to observe the number of mortalities of thrips out of total 12 thrips for each plant. The plant leaves were used to get the essence of plants using 50% alcohol and used it on the leaves in different concentrations. At the same time different duration of mortality of thrips were also observed. The experiment was designed to find out the potentiality of plant extracts for the mortality of thrips based on concentration and duration of time, and also find out the impact of different concentrations of extract on the mortality of thrips among the extracted plants. The plants were collected randomly from different places of Bangladesh. A total of 60 samples (thrips affected leaves), 12 for each plant were used in this study. Using *in vitro* method, 5 ml essence of plants were used for each sample. The laboratory work was carried out in the Department of Food Engineering and Tea Technology of Shahjalal University of Science and Technology, Sylhet, Bangladesh during March, 2019 to August, 2019.

Data analysis was carried out using analysis of variance (ANOVA). One-way ANOVA test is a widely used parametric test that is used to determine whether more than two groups have the same means or not (Osteragova and Ostertag, 2013). In this experimental study, ANOVA was used to find out whether there has significance difference in the average mortality of thrips among the five type of plants for the same concentration. For significance difference in the mortality of thrips for different plants, the Post hoc tests were applied to find out the significantly different pairs of plants extracts. To find out the impact of different concentration on the mortality of thrips, a Poisson regression model was applied. Poisson regression model was applied here because of the nature of the dependent variable, the number of mortalities of thrips which follows approximately a Poisson distribution. However, the Poisson loglinear regression model for the expected number of the occurrence of deaths of the thrips (μ) is: $\log_e \mu = \beta_0 + \beta_1 X$

Where, μ is the number of mortalities of thrips and X is the densities of the concentration (categorical type). Because of the small number of replicates and slight violation of equi-dispersion assumption having under-dispersion among samples, the confidence intervals were found to be more compact which was not major concern

in this study. However, to eliminate the influence of under-dispersion, robust estimates were presented in the results.

## 3. Results and Discussions

The basic results of the study reveal that mortality of thrips from the surveyed leaves provide different mortality rate for different plant extracts because plants are rich source of bioactive organic chemicals. It is estimated that plants may contain as many as 4000,000 secondary metabolites (Mamun, 2011). The anti-pest plants (Radhakrishnan, 2005 and Mugisha- Kamatenesi *et al*., 2008) are used to quantify the mortality rate of thrips in this study for tea pest management. In the study of Ravindran *et al*., 2012, the highest mortality was observed at 45.8% and inhibition fecundify at 10.9% at the highest concentration tested (100 mg/ml) for the ethanolic extract of *C. alata*. Figure 1 illustrates the average mortality rate of thrips for different plants. The higher mortality rates were found as 0.50 and 0.35 for the leaves of *Monochoria vaginalis* and *Nerium odoratum*, respectively while the minimum mortality was found as 0.18 and 0.21 for the leaves of *Mikania cordata* and *Annona squamosa*. However, the average mortality rate of *Cassia alata* was found as 0.30. It is found that there has significance (p=0.005) difference in the average mortality rate of thrips for different plants.

The average time to death were increased significantly (p<0.0000) for the different mortality rate (Figure 2). The average time to occur 25% mortality of thrips was found as 17.90 hours. On average, 23.67 hours was needed to occur more than 75% mortality rate of thrips. About 25% to 50% mortalities were occurred within the average of 21.81 hours. As an average of 23.82 hours were needed for the mortality rate of 50% to 75%.

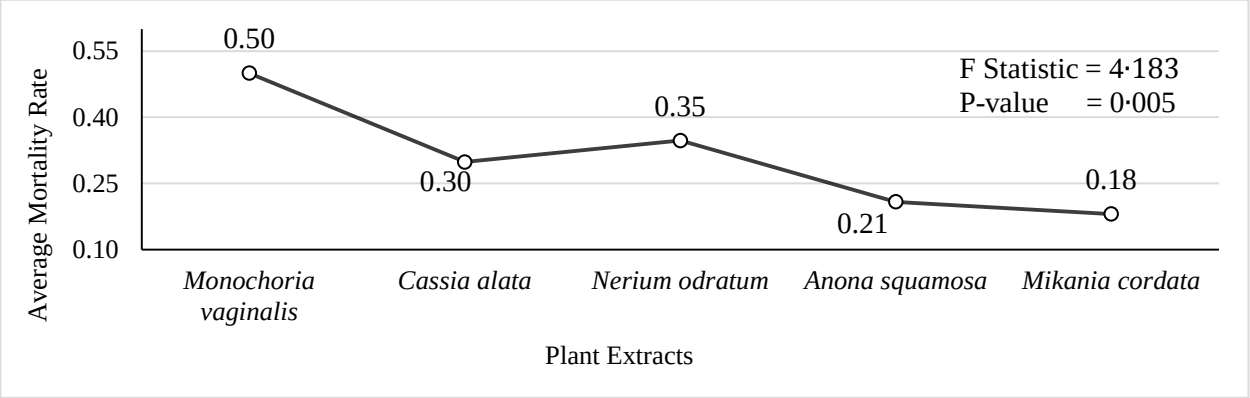


Figure 1. Average Mortality Rate among Different Plant Extracts

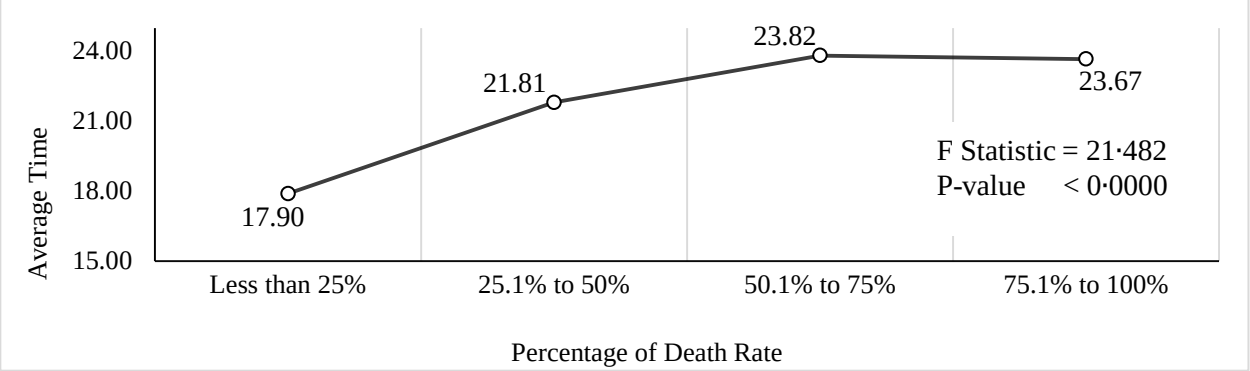


Figure 2. Average Time of Death among Percentage of Mortality Rate

In this experimental study, the efficacy of the plant extracts based on the mortality of thrips was determined by the average time to the percentage of mortality rate and also the ranking which was based on the sample coefficient of variations for 15% concentration. Table 1 shows the average time (in hours) for the different percentage of mortality rate. The average time for the potentiality of thrips mortality were found almost similar for *Monochoria vaginalis*, *Cassia alata* and *Nerium odoratum*. It was found that only *Monochoria vaginalis* had potentiality on more than 75% of the mortality rate of thrips which took an average of 23.7 hours. *Monochoria*

*vaginalis* (23 hours), *Cassia alata* (24 hours) and *Nerium odoratum* (24 hours) have the potentiality on the mortality rates ranges between 0.5 to 0.75 and up to 50% mortality of thrips. At the same time, among the leaf extract of three species of Cassia (*Cassia alata, Cassia occidentalis and Cassia tora*), it seems that *C. alata* is the most potent species for having significant antimicrobial activity (Khan *et al*., 2001; Chatterjee and Dutta, 2010, Chatterjee, 2013; Rahmanan and Muthukumaran, 2019).The study of Obembe and Kayode (2019) revealed that maximum mortality of 100 % was recorded in seeds treated with *C. alata* extract at the dosage level of 4.0 %while highest mortality of 80.30 % was also recorded in seed treated with 4.0 g of *C. alata* powder. *Nerium odoratum* took 18.5 hours for 25% mortality rate and 21.2 hours for up to 50% mortality rate. *Annona squamosa* took 17.0 hours for up to 25% mortality and 21.9 hours for up to 50% mortality rate. *Mikania cordata* had needed 19.6 hours for up to 25% mortality and 23.4 hours for up to 50% mortality rate which is larger than *Annona squamosa*. Though *Mikania cordata* offers excellent hiding places and serves as alternative hosts for tea mosquito bug (Mamun and Ahmed, 2011), this plant has a high mortality rate of thrips. Therefore, based on Table 1, the efficacy of the plant's extracts was ordered as *Monochoria vaginalis, Nerium odoratum, Cassia alata, Annona squamosa* and *Mikania cordata.*

Table 1. Time to death affects in the different mortality rate of thrips for different plant extracts

| | **Percentage of Mortality Rate of Thrips** | | | |
|---|---|---|---|---|
| | Less than 25% | 25.1% to 50% | 50.1% to 75% | More than 75% |
| Plant Extract | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| *Monochoria vaginalis* | 16.6 ± 2.30 | 21.5 ± 3.54 | 23.0 ± 1.41 | 23.7 ± 0.58 |
| *Cassia alata* | 16.5 ± 2.12 | 21.0 ± 3.03 | 24.0 ± 0.00 | - |
| *Nerium odoratum* | 18.5 ± 0.71 | 21.2 ± 3.35 | 24.0 ± 0.00 | - |
| Annona squamosa | 17.0 ± 0.82 | 21.9 ± 2.36 | - | - |
| Mikania cordata | 19.6 ± 2.76 | 23.4 ± 0.55 | - | - |
| **Total** | **17.9 ± 2.40** | **21.81 ± 2.55** | **23.82 ± 0.60** | **23.67 ± 0.58** |

Table 2 represents the results of one-way ANOVA and post hoc test along with sample coefficient of variation for the efficacy of the plants extracts. The results revealed that there had significant difference in the average number of mortalities for different plant extracts within the same density of concentrations (except 1% concentration). However, the efficacy was found similar as the previous results. For 1% concentration of extract, there had no significance difference in the average mortality of thrips between the leaves of the plants. However, with increase of concentration, the average number of mortalities were also increased significantly. For 5% concentration, there had significant difference between *Monochoria vaginalis* and all other plants. The maximum number of mortalities was found as 5.67 for *Monochoria vaginalis*. The average number of mortalities were found almost similar for other four types of plants and ranges from 1.33 to 2 at this density of concentration. As like 5% concentration, there had also significant difference between *Monochoria vaginalis* and all other plants along with another two pairs i.e., *Nerium odoratum* versus *Annona squamosa* and *Nerium odoratum* versus *Mikania cordata*. From the experimented sample, the maximum number of mortalities were also found for *Monochoria vaginalis* (7.67) at 10% concentration. The average mortalities were found as 5.0 and 4.0 for *Nerium odoratum* and *Cassia alata*.

For the maximum density of concentration, it was found that there had significant difference in the average mortalities between the pairs *Monochoria vaginalis* versus *Cassia alata*; *Monochoria vaginalis* versus *Annona squamosa*; *Monochoria vaginalis* versus *Mikania cordata*; *Cassia alata* versus *Annona squamosa*; *Cassia alata* versus *Mikania cordata*; *Nerium odoratum* versus *Annona squamosa* and *Nerium odoratum* versus *Mikania cordata*. The results also revealed that the average mortality was found as maximum (9.67) for *Monochoria vaginalis* than the other plants. The average mortality of *Nerium odoratum* was found as 8.33 which is second in rank of efficacy of plant extract. The third ranked plant was found as *Cassia alata* with average mortality of 7.33. From the rest of two plants *Mikania cordata* was found as the last ranked plants with the lowest estimate of

average mortality (4.33). Therefore, at 10% concentration, the rank was found by following *Monochoria vaginalis*, *Nerium odoratum*, *Cassia alata*, *Annona squamosa* and *Mikania cordata* respectively that is considerable for other medicinal plants like *Ipomoea crassicaulis, Lantana camara, Ipomoea hederaceaa, Glycosmis arborea,* and *Justicia gendarussa* (Azad *et al*., 2020).

Table 2. Number of mortalities of thrips in different concentration of plant extract for different plant extracts

| | **Mortality at Different Concentration of Plant extract** | | | | | |
|---|---|---|---|---|---|---|
| | 1% | 5% | 10% | 15% | | |
| Plant Extracts | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | CV | Ranking |
| *Monochoria vaginalis* | 1.00a ± 0.00 | 5.67a ± 0.58 | 7.67a ± 0.58 | 9.67a ± 0.58 | 5.99 | **1** |
| *Cassia alata* | 1.00a ± 0.00 | 2.00b ± 0.00 | 4.00bc ± 0.00 | 7.33b ± 0.58 | 7.91 | **3** |
| *Nerium odoratum* | 1.33a ± 0.58 | 2.00b ± 0.00 | 5.00b ± 1.00 | 8.33ab ± 0.58 | 6.96 | **2** |
| *Annona squamosa* | 0.33a ± 0.58 | 1.33b ± 0.58 | 3.00c ± 0.00 | 5.33c ± 0.58 | 10.88 | **4** |
| *Mikania cordata* | 0.33a ± 0.58 | 1.33b ± 0.58 | 2.67c ± 0.58 | 4.33c ± 0.58 | 13.39 | **5** |
| **Total** | **0.80 ± 0.56** | **2.47 ± 1.73** | **4.47 ± 1.92** | **7.00 ± 2.07** | **-** | **-** |

Means within column followed by the same letters are not significantly different based on Tukey's Post Hoc (Liu,et al. 2015) test at p = 0.05.

Poisson regression was used in Table 3 to determine the significant impact of different densities of concentration on the mortality of thrips for the plant extracts. The table shows the parameter estimates of the Poisson regression model along with Wald 95% confidence interval. The Omnibus test revealed that the different concentrations of alcohol have significant effect on the number of mortalities of thrips. The number of deaths of the thrips was found almost three times higher (Exp(1.126)=3.083) for 5% concentration than the 1% concentration of extract. The deaths were found as almost 5.5 times higher (Exp(1.72)=5.583) in 10% concentration as compared to 1% concentration. However, for further increase of the centration (15%), the number of deaths were increases as 8.75 times (Exp(2.169)=8.75) than the lowest densities of concentration (1%).

Table 3. Estimates of Poisson Regression Model along with 95% Confidence Interval

| **Parameters** | **Estimates, β** | **95% CI of β** | **Exp(β)** | **95% CI of Exp(β)** |
|---|---|---|---|---|
| Intercept | -0.223 | [-0.566, 1.119] | 0.800 | [0.568, 1.127] |
| 1% Concentration (Reference group) | | | | |
| 5% Concentration | 1.126 | [0.642, 1.610] | 3.083 | [1.900, 5.004] |
| 10% Concentration | 1.720 | [1.318, 2.122] | 5.583 | [3.735, 8.346] |
| 15% Concentration | 2.169 | [1.797, 2.541] | 8.750 | [6.003, 12.691] |

Omnibus test result: Likelihood Ratio Chi-square = 94.36, P-value <0.0000

## 4. Conclusion

Five types of medicinal plant extracts were used in this study to find out the potentiality of extracts on tea thrips at different concentrations. It was found that the plant extracts had potential to control the tea thrips (on mortality) based on time and concentration. Only *Monochoria vaginalis* had potentiality on more than 75% of the mortality rate of thrips which took an average 23.7 hours. Result shows that *Monochoria vaginalis* had the minimum CV value (5.99) than *Nerium odoratum*, *Cassia alata*, *Annona squamosa* and *Mikania cordata*. So, *Monochoria vaginalis* extracts was found to be most potential plant depending on the time of death affect among the five medicinal plants used in this study.

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# Some Biological Parameters of Asian Stinging Catfish, *Heteropneustes fossilis* (Bloch, 1794) (Teleostei: Siluriformes) in the Padma River

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## Abstract

The Stinging catfish, *Heteropneustes fossilis* (Bloch, 1974) is a commercially important fish species in Asia. The present study reveals life history traits of *H. fossilis* including population structure, growth pattern (length-weight relationships, LWRs; length-length relationship, LLR), conditions, prey-predator status (relative weight, $W_R$), form factor ($a_{3.0}$), size at first sexual maturity ($L_m$) and natural mortality ($M_W$) of *H. fossilis* from the Padma River, northwestern Bangladesh. A total of 344 individuals of *H. fossilis* were captured by various types of traditional fishing gears during July 2018 to June 2019 and measured biometric data for each individual. The recorded results showed that the total length was varied from 8.50 to 28.70 cm and Body weight was ranged from 3.12 to 146.55 g. All LWRs were significant ($p$<0.001), with $r^2$ values ≥ 0.968. The calculated allometric coefficient ($b$) showed positive allometric growth in combined sexes ($b$ > 3.00). The LLR was significant ($p$<0.001) with $r^2$ value > 0.995. The $a_{3.0}$, $L_m$, and $M_W$ were 0.0060, 16.45 cm TL and 0.93 per year for *H. fossilis* in the Padma River, respectively. These findings would be very effective for further stock assessment and management of this fish in the Padma River and adjoining ecosystems.

**Keywords:** Growth Pattern; *Heteropneustes fossili;* Size; Sexual Maturity; Natural Mortality.

## 1. Introduction

The stinging catfish belongs to the family Heteropneustidae under the order Siluriformes (locally called *shing, shinghi*) is primarily a fish of ponds, ditches, beels, swamps and marshes but sometimes found in muddy rivers (Jha and Rayamajhi, 2010; Froese and Pouly, 2019). This fish is locally known as *Singi* in Bangladesh (Talwar and Jhingran, 1991). It is an indigenous species in Asian countries including Bangladesh, India, Nepal, Pakistan, Sri Lanka, Myanmar and Thailand (Talwar and Jhingran, 1991). It is commercially important as a popular food fish. It is caught by small-and large-scale commercial fishers operating in the Padma River with a variety of traditional fishing gears (Craig *et al.,* 2004; Hossain, 2010). The conservation status of this catfish has been categorized as a species of least concern in Bangladesh (IUCN Bangladesh, 2015) and worldwide (IUCN, 2017). Information on population parameters i.e., growth, reproduction, recruitment as well as mortality of fishes is vital to the implementation of sustainable management strategies for their better conservation (Rahman *et al.*, 2012; Hossain *et al.*, 2012a, 2015, 2016). A sum of studies including length-length relationship, length-weight relationships (LWRs) and condition factors (Muhammad *et al.*, 2012; Alam and Ferdaushy, 2015; Das *et al.*, 2015; Hossain *et al.*, 2017; Khan *et al.*, 2012) of this fish species have been conducted, but to the best of authors' knowledge to date, there is no previous studies on this aspects of *H. fossilis* from Padma River of Bangladesh. Therefore, the present study was aimed to describe some biological parameters including, population structure, growth pattern, best condition factor, prey-predator status, form factor ($a_{3.0}$), size at first sexual maturity ($L_m$) and natural mortality ($M_w$) of *H. fossilis* in the Padma River, northwestern part of Bangladesh using a number of specimen with various sizes over the study period of one year.

## 2. Materials and Methods

### 2.1. Sampling and Measurement

The present study was carried out in the Padma River in Bangladesh (Charghat: 24°15' N, 88°44' E; and Shaheb Bazaar: 24°20' N, 88°34'), northwestern part of Bangladesh. Samples of *H. fossilis* were collected occasionally from the fishers' catch during July 2018 to June 2019. The random sampling method was used for sampling of fish. This fishes typically captured by using different types of traditional fishing gears like, gill net, cast net,

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square lift net, etc. Collected specimens were instantly chilled in ice on site and preserved with 10% buffered formalin upon arrival in the laboratory. For each individual total length (TL) and standard length (SL) were taken to the nearest 0.01 cm by using digital slide calipers, and body weight (BW) was measured to the nearest 0.01 g by using an electric balance with 0.01 g accuracy.

### 2.2. Population Structure

The LFD for the *H. fossilis* was constructed using 1 cm intervals of TL. Based on Hasselblad's maximum-likelihood method (Hasselblad, 1966) the normal distribution was fitted to TL frequency distributions.

### 2.3. L-W Relationships

In order to length weight relationships this equation was used: $BW= a*(TL)^b$, where BW is the total body weight (g) and TL is the total length (cm). The parameters *a* and *b* were calculated by linear regression analyses based on natural logarithms: $ln\ (BW) = ln\ (a) + b\ ln\ (TL)$. Extremes outliers were deleted from the regression analyses according to Froese (2006). Additionally, on the basis of the *b* values of LWR (TL vs. BW), growth pattern of *H. fossilis* was determined.

The allometric condition factor ($K_A$) was calculated using the equation of Tesch (1968). The Fulton's condition factor ($K_F$) was calculated using the equation of Fulton (1904). The scaling factor of 100 was used to bring the $K_F$ close to unit and the relative condition factor ($K_R$) for each individual was calculated using the equation of Le Cren (1951).

### 2.4. Prey-Predator Status and Form Factor ($a_{3.0}$)

The prey-predator status of *H. fossilis* was determined through the relative weight ($W_R$). The $W_R$ was calculated by the equation given by Froese (2006). The form factor ($a_{3.0}$) for *H. fossilis* was calculated using the expression given by Froese (2006).

### 2.5. Size at First Sexual Maturity ($L_m$) and Natural Mortality ($M_W$)

The $L_m$ of *H. fossilis* in the Padma River was calculated by using the equation of Binohlan and Froese (2009). The $M_W$ was considered by the model of Peterson and Wroblewski (1984).

### 2.6. Statistical Analysis

For statistical analysis, GraphPad Prism 6.5 Software was used. The Wilcoxon signed rank test was applied to compare the mean relative weight ($W_R$) with 100 (Anderson and Neumann 1996). Additionally, data analyses were done through Microsoft-Excel-add-in-Solver. All statistical analyses were considered significant at 5% ($p<0.05$).

## 3. Results

### 3.1. Population Structure

Descriptive statistics for length and weight of 344 *H. fossilis* and their 95% confidence limit (CL) are showed in Table 1. The length frequency distribution (LFD) displayed that the smallest and largest individuals were 8.50 cm and 28.70 cm in TL, respectively; while the BW ranges from 3.12 to 146.55 g. The TL size group 16.00 to 17.00 cm was numerically dominant and constituted 16.9% of the total population, given in Figure 1.

Table 1. Descriptive statistics on the length (cm) and weight (g) measurements of *H. fossilis* from Padma River, northwestern Bangladesh

| Measurements | *n* | Min (cm) | Max (cm) | Mean ± SD (cm) | 95% CL (cm) |
|---|---|---|---|---|---|
| TL | 344 | 8.5 | 28.7 | 14.91±3.56 | 11.36 to 18.47 |
| SL | | 7.5 | 26.6 | 13.41±3.26 | 10.16 to 16.67 |
| BW | | 3.12* | 146.55* | 21.89±22.65* | -0.76 to 44.53* |

TL, total length; SL, standard length; BW, body weight; *n*, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values, *, weight in g.

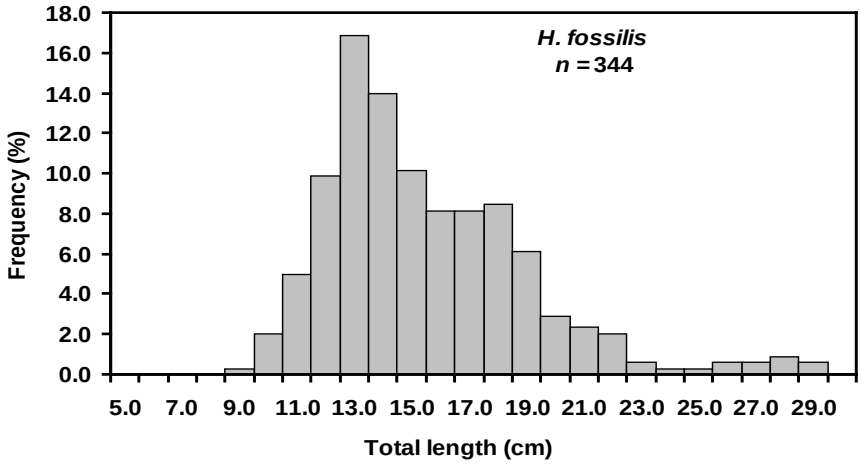


Figure 1. The length-frequency distribution of *H. fossilis* in the Padma River, NW Bangladesh.

### 3.2. Length- weight Relationship

The regression parameters of the LWR, 95% CL of *a* and *b*, the coefficient of determination ($r^2$) and growth pattern of *H. fossilis* are given in Table 2 and in Figures 2 and 3. The *b* value 3.37 and 3.28 of LWRs (TL *vs.* BW; SL *vs.* BW) indicates positive allometric growth. All LWRs were highly significant ($p < 0.001$) with $r^2$ values ≥ 0.968. Based on the maximum $r^2$ value, LWR by BW *vs.* TL was the best fitted model among the equations. Also, the *b* value 1.07 of LLR (TL *vs.* SL) indicates positive allometric growth (Fig. 3). LLRs were highly correlated with $r^2$ values ≥ 0.995.

Table 2. Descriptive statistics and estimated parameters of the total length (TL), standard length (SL) and body weight relationship of the *H. fossilis* from Padma River, northwestern Bangladesh

| Equation | *n* | Regression parameters | | 95% CL of *a* | 95% CL of *b* | $r^2$ | GT |
|---|---|---|---|---|---|---|---|
| | | *a* | *B* | | | | |
| BW=$a$×TL$^b$ | 344 | 0.0019 | 3.37 | 0.0016 - 0.0022 | 3.31 - 3.43 | 0.972 | +A |
| BW=$a$×SL$^b$ | | 0.0035 | 3.28 | 0.0029 - 0.0041 | 3.21 - 3.34 | 0.968 | +A |

*n* sample size; BW, body weight; SL, standard length; *a* and *b* are regression parameters and $r^2$, co-efficient of determination and GT, growth type: (+A, positive allometric).

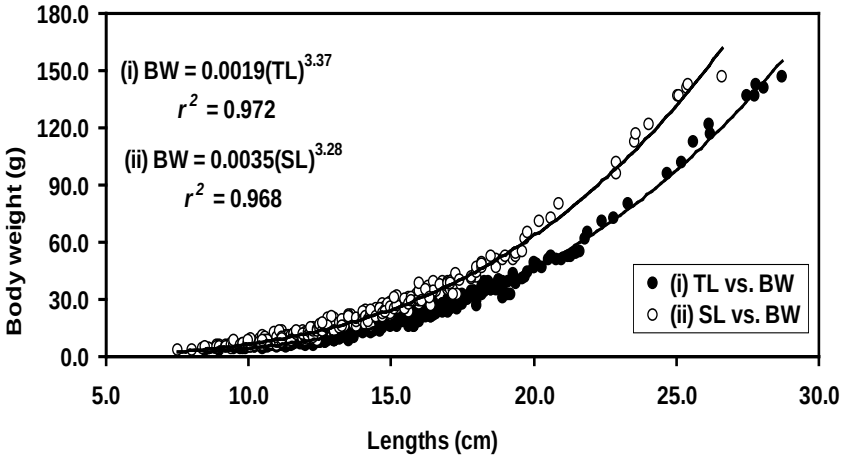


Figure 2. The length-weight relationships (BW = $a*TL^b$) of *H. fossilis* in the Padma River, NW Bangladesh.

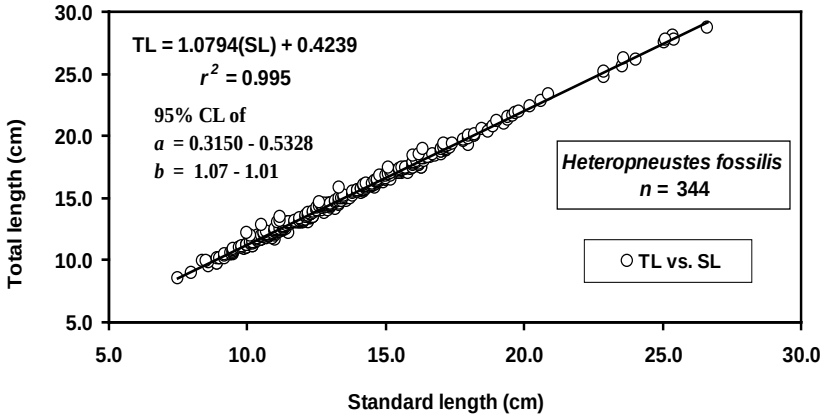


Figure 3. The length-length relationships (TL = *a* + *b** SL) of *H. fossilis* in the Padma River, NW Bangladesh.

### 3.3. Best Condition Factors (CF) and Form Factor ($a_{3.0}$)

The values of all condition factors ($K_A$, $K_F$, $K_R$, and $W_R$) are given in Table 3. The present study revealed that the $K_A$ value ranged from the 0.0013 to 0.0027, with mean value of 0.0019 ±0.0002 (95% CL= 0.0017 - 0.0022), $K_F$ value ranged from the 0.319 - 0.700 with mean value of 0.517 ±0.076 (95% CL= 0.441 - 0.593), $K_R$ value ranged from the 0.665 - 1.465 with mean value of 1.012 ±0.128 (95% CL= 0.883 – 1.139) and $W_R$ value ranged from the 66.549 - 146.438 with mean value of 101.070 ±12.979 (95% CL= 88.273 – 113.868), respectively. $W_R$ was no significant different from 100 ($p$=0.949) for *H. fossilis* in the Padma River (Figure 4). The form factor ($a_{3.0}$) was observed as 0.0060 (Table 5) in the Padma River, NW Bangladesh.

Table 3. Condition factors; Fulton′s condition factor ($K_F$), Allometric condition factor ($K_A$), Relative condition factor ($K_R$) and Relative weight ($W_R$) of *H. fossilis* (n=344) from Padma River, northwestern Bangladesh

| Condition factors | *n* | Min | Max | Mean ± SD | 95% CL |
|---|---|---|---|---|---|
| $K_F$ | 344 | 0.319 | 0.700 | 0.517±0.076 | 0.441 - 0.593 |
| $K_A$ | | 0.0013 | 0.0027 | 0.0019 ± 0.0002 | 0.0017 - 0.0022 |
| $K_R$ | | 0.665 | 1.465 | 1.012 ± 0.128 | 0.883 - 1.139 |
| $W_R$ | | 66.549 | 146.483 | 101.070 ± 12.797 | 88.273 - 113.868 |

*n*, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values; $K_A$, allometric condition factor; $K_F$, Fulton′s condition factor; $K_R$, relative condition factor; $W_R$, relative weight.

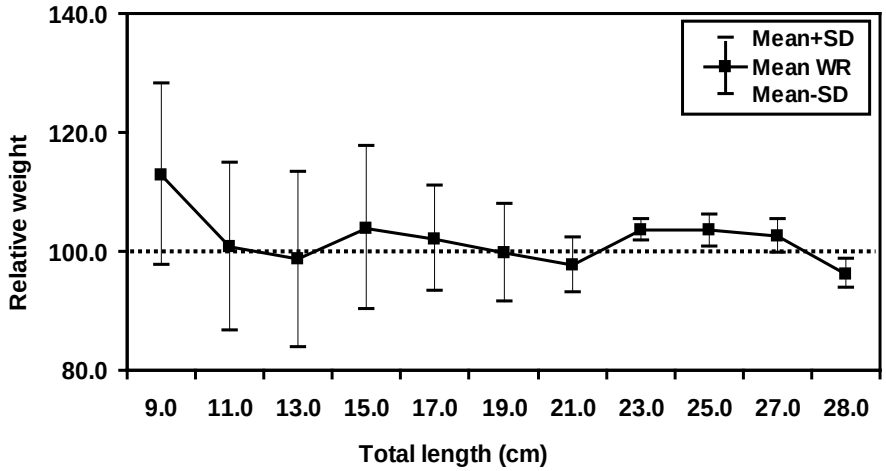


Figure 4. Relative weight of *H. fossilis* in the Padma River, NW Bangladesh.

### 3.4. Size at First Sexual Maturity ($L_m$) and Natural Mortality ($M_w$)

The $L_m$ of *H. fossilis* in the Padma River was calculated as 16.45 cm in TL with 95% CL = 12.80-21.04 cm. The $M_W$ of *H. fossilis* in this study was estimated as 0.93 year$^{-1}$ in the Padma River (Table 4 and Figure 5).

Table 4. The calculated form factor ($a_{3.0}$), size at first sexual maturity ($L_m$) and natural mortality ($M_w$) for of *H. fossilis* from Padma River, northwestern Bangladesh

| Sex | *n* | Total Length (cm) | | *a* | *b* | $a_{3.0}$ | $M_w$ | $L_m$ | 95% CL of $L_m$ |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | | | | | | |
| Combined | 344 | 8.5 | 28.7 | 0.0019 | 3.37 | 0.0060 | 0.93 | 16.45 | 12.80-21.04 |

*n*, sample size; TL, total length; Min, minimum; Max, maximum; *a*, intercept; *b*, slope; $a_{3.0}$, form factor; $L_m$ size at first sexual maturity; CL, confidence limit.

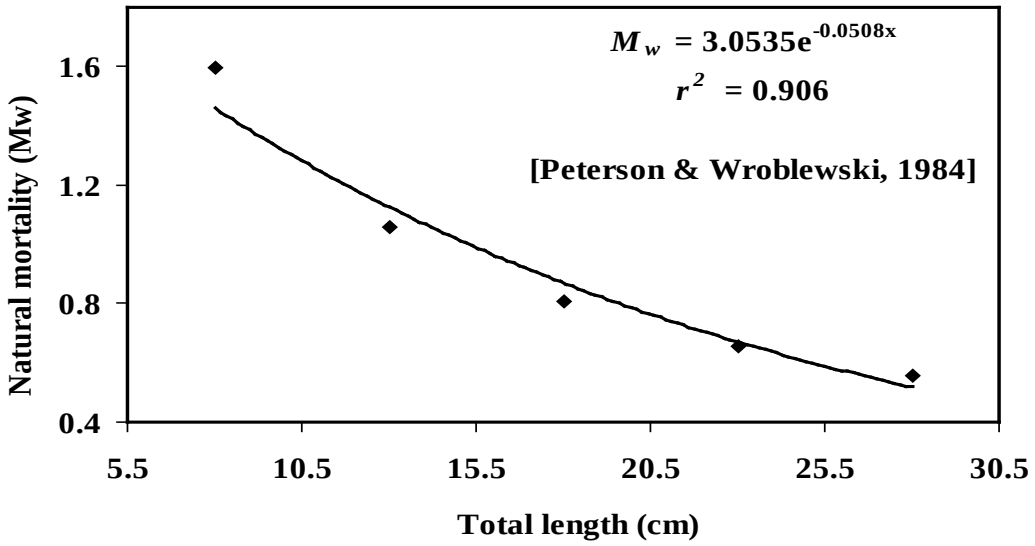


Figure **5.** Natural mortality of *Heteropneustes fossilis* in the Padma River, NW Bangladesh.

### 4. Discussion

Information on life-history traits of *H. fossilis* is scant in literature from Bangladesh and elsewhere. However, the present study focuses on the complete life-history traits of *H. fossilis* including population structure, growth pattern, best condition factor, relative weight ($W_R$), form factor ($a_{3.0}$), size at first sexual maturity ($L_m$) and natural mortality ($M_w$) collected from the Padma River, a largest River of Bangladesh using a number of specimens with small to large body sizes through traditional fishing gears. However, it was not possible to catch *H. fossilis* smaller than 8.5 cm TL during the sampling period, which can be attributed either to the absence of small sized fishes (< 8.5 cm TL) in the populations or selectivity of fishing gears (Hossain *et al.*, 2012b). In our present study, the maximum length of *H. fossilis* was recorded as 28.7 cm in TL which is lower than the maximum reported value of 31.0 cm in TL in the Ganga River, India (Khan *et al.*, 2012). Information on maximum length is necessary to estimate the population parameters including asymptotic length and growth coefficient of fishes, which is important for fisheries resource planning and management (Hossain *et al.*, 2012a, Khatun *et al.*, 2018, 2019; Parvin *et al.*, 2018).

Generally, the *b* values in LWRs should remain within the range of 2.5–3.5 (Froese, 2006); in this study all the *b* values fall within this expected range. In general *b* values close to 3, indicating that fish grow isometrically and different from 3.0 indicate allometric growth (>3 positive allometric and <3 negative allometric) (Tesch, 1971). In the present study, *b* values ranges from 3.28-3.37 indicating positive allometric growth for *H. fossilis* in the Padma River, northwestern part of Bangladesh. Similar growth pattern was observed by Khan *et al.*, (2012)

(*b*=3.14) from the Ganga River, India. However, Hossain *et al.* (2017) reported isometric growth (*b*= 3.01) in the Gajner *Beel* which is quite difference with the present study. The data of *H. fossilis* were collected over an extended period of time and data were not representative of any particular season, so it should be treated only as mean-annual values for comparative purposes. The LLR of *H. fossilis* are highly correlated. However, there is no prior study dealing with LLR restrain the comparison with other study.

In our study, four condition factors (allometric condition factor, Fulton condition factor, relative condition factor and relative weight) were studied to assess the health and habitat condition of *H. fossilis* in the Padma River. However, based on largest value of correlation coefficient, Fulton condition factor was the best for assessing the wellbeing of this species in the Padma River. Additionally, relative weight was not significantly different from 100 (*P*=0.949) indicating an ideal habitat with the availability of food and lower predators for *H. fossilis* in the Padma River.

The $a_{3.0}$ can be used to confirm whether the body shape of individuals in a given population or species is considerably different from others (Froese, 2006). The $a_{3.0}$ was 0.0060 indicating elongated body shape for *H. fossilis* in the Padma River. There was no reference regarding the form factor of this species in the literature, and this is the first study on this regard, which will provide the foundation for future studies.

The size at first sexual maturity ($L_m$) of *H. fossilis* was 16.45 cm in TL. Studies on $L_m$ for the fishes of Bangladeshi waters are very rare (except Hossain *et al.,* 2010, 2012c). There was no previous studies on $L_m$ hindering the comparison with others.

In the present study, the $M_w$ of *H. fossilis* was calculated as 0.93 per year in the Padma River. However, due to lack of available literature regarding $M_w$ of *H. fossilis* restrains the comparison with the others.

## 5. Conclusion

This study was presented the life history traits of *H. fossilis* including population structure, growth pattern, best condition factor, prey-predators status, form factor, size at first sexual maturity and natural mortality, which would be an effective tool for fishery managers, fish biologists and conservationists to initiate early management strategies and regulations for the sustainable conservation of the remaining stocks of this species in the Padma River and surrounding ecosystems.

## Acknowledgments

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# Evaluation of Groundwater Quality in Bagerhat District, Bangladesh

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## Abstract

Groundwater quality in Bagerhat district of Bangladesh was assessed during pre-monsoon and post-monsoon period of the year 2016. The study is aimed to find out the seasonal water quality of groundwater which shows most of the parameters values of the samples were decreased during post-monsoon period due to the dilution of monsoon rainfall water. To fulfill the research objectives, some significant physicochemical parameters of groundwater have been analyzed and interpreted in the study. Among the physical parameters of the most samples of both seasons, the pH and TH values are within the WHO and DoE's allowed limits except few samples of post-monsoon; However in the most samples, the values of EC and TDS exceeded this recommended limit, except for a few samples for subsequent samples during the monsoon . Among the chemical parameters, $Na^+$ and $Cl^-$ values of all the samples exceeded WHO and DoE permissible limit, while $Ca^{2+}$, $Mg^{2+}$, $SO_4^{2-}$ and $NO_3^-$ values are significantly low and their values are below the WHO and DoE's permissible limit but $K^+$ and $HCO_3^-$ values for few samples are below, some are within the permissible limit and some are exceeded the WHO and DoE's permissible limit. So the water quality controlling parameters especially EC, TDS, $Na^+$, and $Cl^-$ absorbency are objectionable in the most of the groundwater specimens which exceeding the WHO (2006) and DoE (1997) standards and unlikely for drinking and irrigation purposes. The Pie study also shows that the order of the abundance of major cations in the ground water is $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ while that of anions is $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ in both periods in the area. Overall, the results revealed that the groundwater quality in the study area is objectionable and unsuitable for drinking, domestic and agriculture purposes.

**Keywords:** Coastal Area; Groundwater; Hydrochemistry; Quality Measurement

## 1. Introduction

Groundwater is the main source of freshwater to use in agricultural, industrial and drinking purposes in Indian subcontinent (Azaza *et al.,* 2011). One-thirds of the world population use groundwater for drinking and other purposes (Nickson *et al.,* 2005). The South-West zone of Bangladesh comprises of 21 districts and have very complex river network along with other water bodies like Beels, Wetlands and Khals, however among 21 districts 7 districts are in direct interaction with the Bay of Bengal and can be classified as Coastal zone of South-West part of Bangladesh (Ahmed *et al.,* 2014). Among 7 districts Bagerhat is one of them. The southern part of Bangladesh is vulnerable to natural disasters, and groundwater quality of this region has been deteriorating day-by-day (Islam *et al.,* 2016). Ground water in the coastal area is relatively vulnerable to the contamination by the seawater intrusion (Rani and Babu, 2007). The water quality parameters are the key concern which needs to be informed to citizens and policy makers to ensure conservation and utilization of resources (Hosseinifard and Aminiyan, 2004). Fresh or drinking water is unavailable in a major part of the study area , where local peoples are using or drinking polluted surface water without proper purification (Researcher field observation, 2016). So it is very important to find out the groundwater quality of Bagerhat district. Generally water quality depends on physical, chemical and biological properties of water. However biological properties have been neglected in the study due to researcher's limitation. So, physicochemical analysis has considered evaluating the groundwater quality in the study area. The study result has been compared with WHO (2006) and DoE (1997) permissible standard limit to measure water quality for drinking, agriculture and domestic purposes. The main objective of the present study is to evaluate the groundwater quality of the study area.

### 1.1 Study Area

The research work has been scheduled in the coastal adjoining "Bagerhat district" including 9 (Nine) Upazillas having area of 3959.11 sq. km (P&HC, 2011). The Upazilas are Mollahat, Fakirhat, Chitalmari, Kachua, Rampal,

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Mongla, Morrelganj and Sarankhola. The area is bounded by Gopalganj district and Norail district on the north, the Bay of Bengal on the south, Perojpur and Barguna district on the east and Khulna district on the west shown in figure1 and which is located between 22°48' N to 22°59'N latitudes and 89°40' E to 90°57' E longitudes formed primarily by the deposition of late Holocene to Recent sediments carried by the Ganges-Brahmaputra-Meghna Rivers.

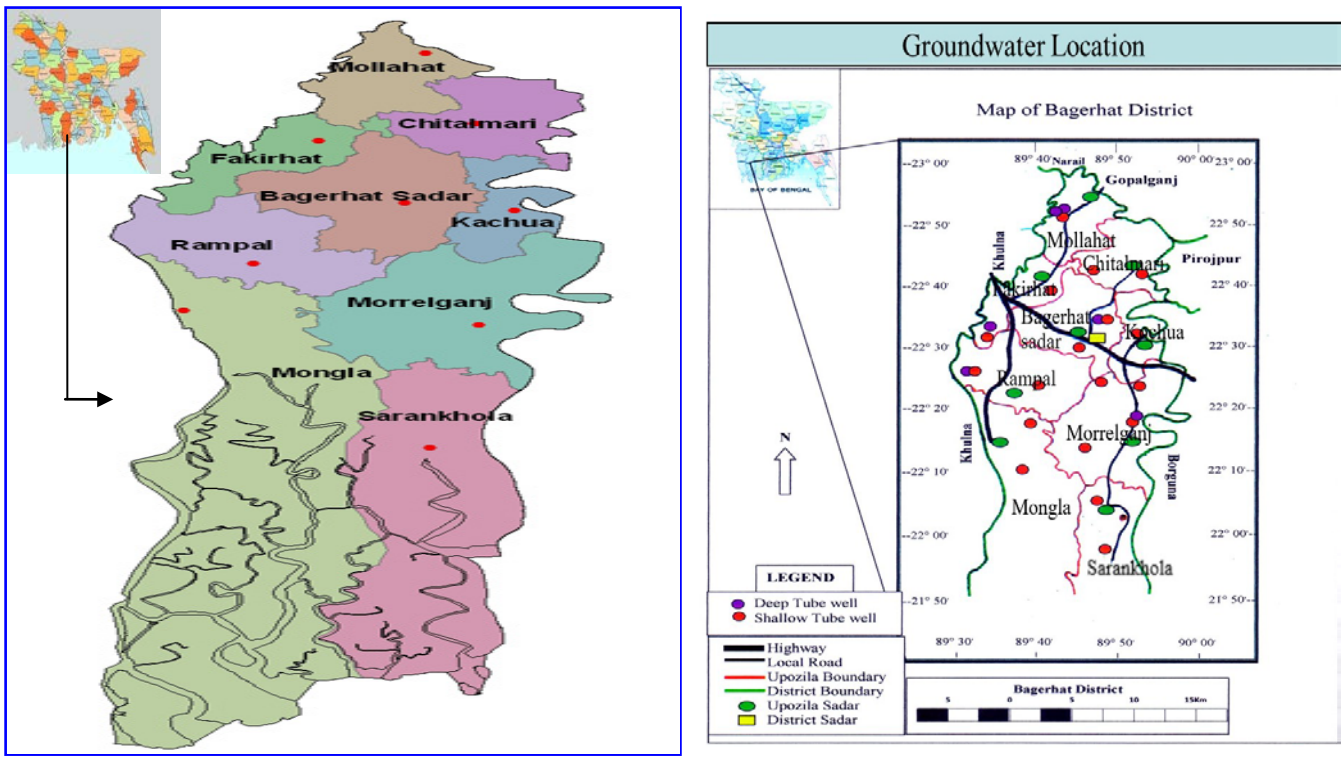



Figure 1: Bagerhat District map and Sampling stations.

## 2. Materials and Methods

Twenty four samples were collected from domestic area of different location in the study area during pre-monsoon (May) and post-monsoon (November), 2016 by the following of Shafiuzzaman and Haque (2015). Samples are collected in 500 ml high-density polypropylene (HDPP) bottles. Color, taste and odor are tested by necked eye, tongue and nose. Temperature was collected by Toshiba Mercuric Thermometer. pH was measured by pH meter (HANNA pH-209 & EZ-DO-6011, SN-000367, Model-IP57, Made in Taiwan). EC was measured by EC meter (HANNA EC & TDS, S-349456, and Model-98312). TDS, TH, SAR, Salinity and %Na measured by recommended equations. $Na^+$, $Ca^{2+}$, $Mg^{2+}$ and $K^+$ were analyzed by AAS method (Atomic Absorption-Spectrophotometer, Model: Simadzu AA-6800). $Cl^-$ and $HCO_3^-$ were analyzed by Titration Method. $SO_4^{2-}$ and $NO_3^-$ were analyzed by Sulfaver-4 Sulphate Method (HACH, Model: DR-3900) and Cadmium Reduction Method (HACH, Model DR-3900). Most of the parameters analyzed in the Laboratory of Institute of Environmental Science Lab, RU; in the Environmental Science and Technology Lab (JUST) Jessore and in the Soil Resource Development Institute (SRDI), Rajshahi.

## 3. Result and Discussion

### 3.1. Physical Properties

The investigated result showed that most of the samples color is normal and some are light brown, brown and black during pre-monsoon period and in the post-monsoon their color is also same. The sample is classified based on EC which is followed by Sallam and Elsayed, 2015; the groundwater samples are slightly saline and medium saline water during pre-monsoon period and in the post-monsoon period all the groundwater samples are slightly saline water. In the pre and post monsoon period groundwater samples have shown various types odors. One of the most important characters of ground water is temperature. The average groundwater temperature is 29.61°C

in pre-monsoon and 26.82°C in post-monsoon period (Figure 2a). The average pH values are 7.81 in pre-monsoon and 6.79 in post-monsoon period (Figure 2b). Electrical conductivity (EC) is a measurement of dissolved material in an aqueous solution, which relates to the ability of the material to conduct electrical current through it. In the present study, average EC value is 3147.50 µS/cm in pre-monsoon period and 1610.05µS/cm in post- monsoon period. The result of EC values show that the EC is decreased remarkably in post-monsoon period than pre-monsoon period and the average highest EC found at Sarankhola Thana and the lowest at Mollahat Thana in both season in the area (Figure 2c). Basically, the penetration of rainwater into the ground reduces the concentration of ions in the groundwater. For this reason, the value of EC is less in post-monsoon. On the other hand, the value of EC is higher in pre-monsoon as the density of ions is higher. The average TDS is 2018.83 mg/l in pre-monsoon period and 1071.3 mg/l in post-monsoon period (Figure 2d). The average TH is 192.50 mg/l in pre-monsoon period 111.48 mg/l in post-monsoon period (Figure 2e). Actually, the values of TDS and TH are different due to the high or low concentration of the chemical elements present in the water before and after the rainy season.

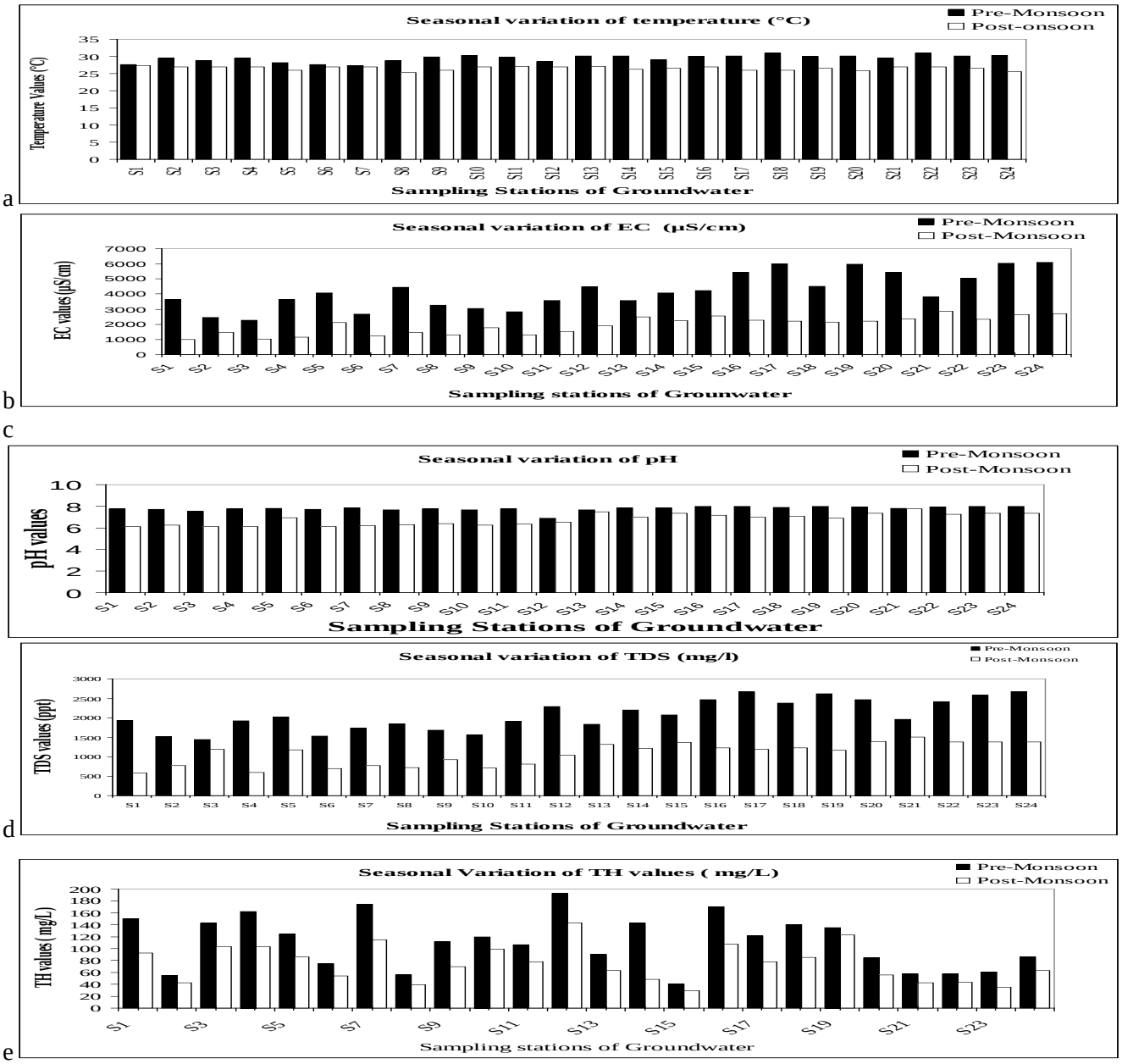
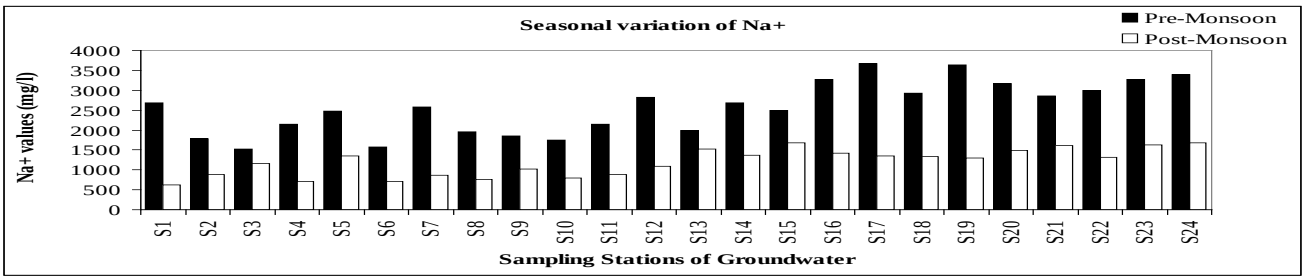


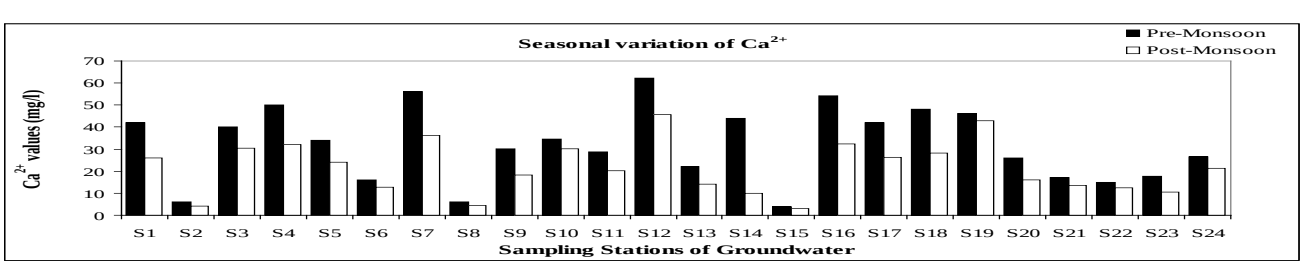

**Figure 2:** The seasonal variation of major physical properties in G.W of the area.

### 3.2. Chemical Properties

The average result of Na+ absorbency of groundwater in the study area is 2569.15 mg/l before rainy seasons, while the highest value is found at the Sarankhola and the lowest value found at Chitalmari Thana, after the rains of the same year those values goes down to average of 1216.72 mg/l, while the highest value is found at Sarankhola and the lowest at Mollahat Thana (Figure 3a). The average calcium concentration in groundwater is 32.72mg/l in pre-monsoon period, which remarkably decline during post monsoon period and shows average 21.88 mg/l (Figure 3b). The average magnesium concentration is of 7.30 mg/l in pre-monsoon which is slightly decline during post monsoon period and shows 5.14 in mg/l (Figure 3c). In addition the average potassium concentration is 14.26 mg/l in pre-monsoon period and 11.76 mg/l shows during post-monsoon period (Figure 3d). On the other hand, average chloride concentration of the groundwater is 3913.13 mg/l in pre-monsoon period and 1797.12 mg/l in the post-monsoon period where the highest value found at Sarankhola Thana and the lowest at Fakirhat Thana during both seasons (Figure 3e). The average Bicarbonates value is 338.89 mg/l in monsoon period, which significantly decline during post-monsoon period and 181.02 mg/l shows in the area (Figure 3f). However the average sulfate values shows 6.82 mg/l during pre- monsoon and 5.13 mg/l shows during post-monsoon period (Figure 3g). The average nitrate concentration in groundwater of the area is 3.85 mg/l and 4.12 mg/l during pre-monsoon and post-monsoon period respectively (Figure 3h). The study result observed that most of the cations and anions concentrations in groundwater of the area are significantly decreasing during post-monsoon period due to monsoon rainwater dilution. The main reason for fluctuation of physicochemical properties of groundwater is not only seasonal variation but also many reasons. Seawater intrusion in coastal aquifer systems is a natural process where seawater replaces groundwater that has been over exploited (Safdar *et al.,* 2019). Surface water resources, like rivers and canals, are severely affected by the intrusion of saline water. Owing to less precipitation and diminished river flow, the saltiness of surface water bodies such as waterways and canals increases through dry season (Shammi *et al.,* 2019). Contamination of water occurs by varying degrees of salinity from rising sea levels, cyclone and storm surges, and upstream withdrawal of freshwater (Khan *et al.,* 2011). In addition, cyclones and tidal surges cause water logging in the area most of the time and salt water is constantly recharged underground due to low tide, especially in pre-monsoon, as the groundwater level drops considerably at that time (Field observation by authors). So for all these reasons the amount of Na+ and Cl- in water is the highest and the amount of other ions is the lowest that is why pre-monsoon and post-monsoon are showing wide variation. The mean values of major cations and anions in milligrams per liters also observed that $Na^+$ and Cl- are the dominant ions in both pre and post monsoon periods that exceeded 90% of total cations and anions in the area (Figures 4a & 4b) and (Figures 5a & 5b) . The pie result also showed that the order of the abundance of major cations in the ground water of the area is $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$, while that of anions is $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ in pre and post monsoon periods.

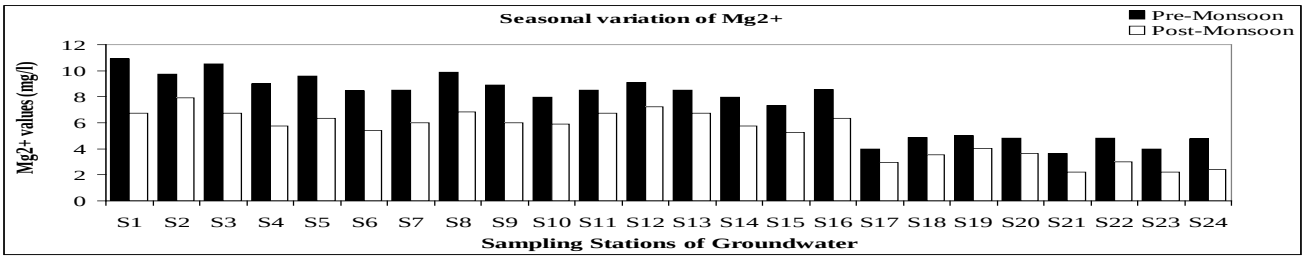



a

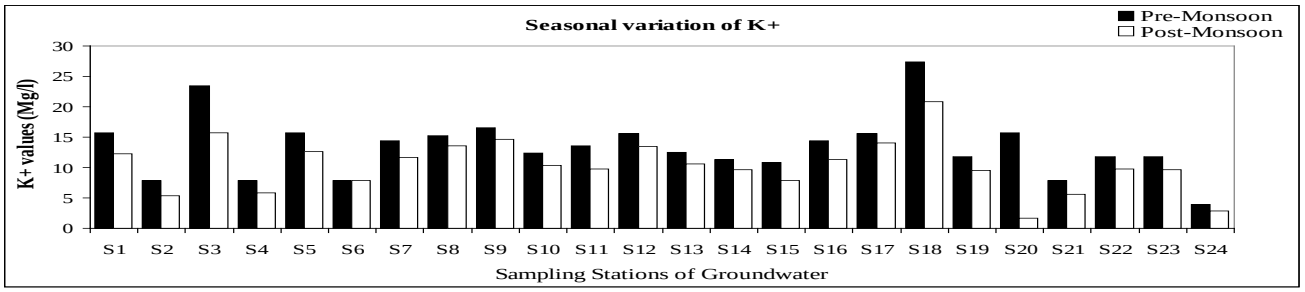



b

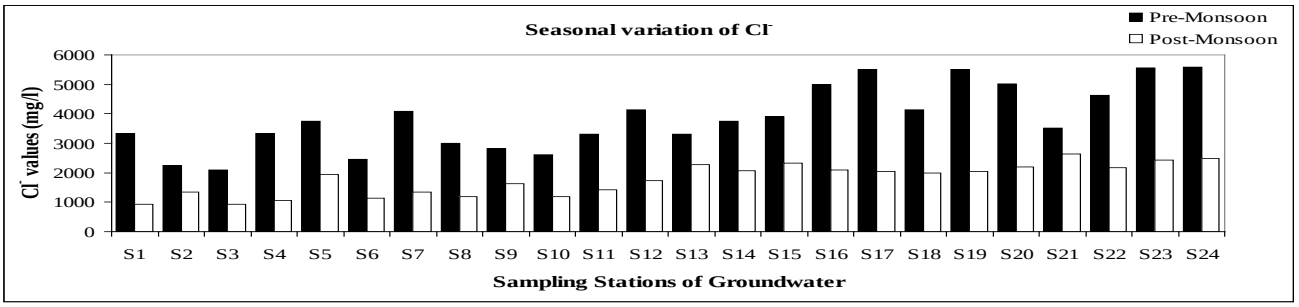
c


Seasonal variation of Mg2+
Pre-Monsoon
Post-Monsoon
Mg2+ values (mg/l)
0 2 4 6 8 10 12
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24
Sampling Stations of Groundwater

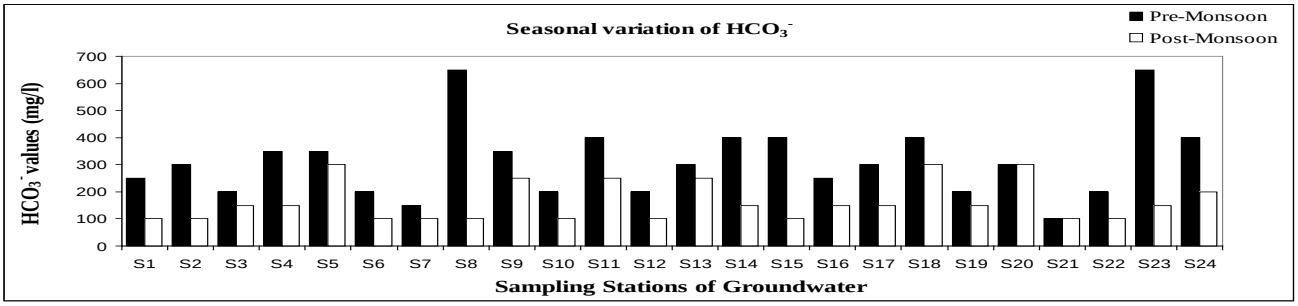
d


Seasonal variation of K+
Pre-Monsoon
Post-Monsoon
K+ values (Mg/l)
0 5 10 15 20 25 30
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24
Sampling Stations of Groundwater

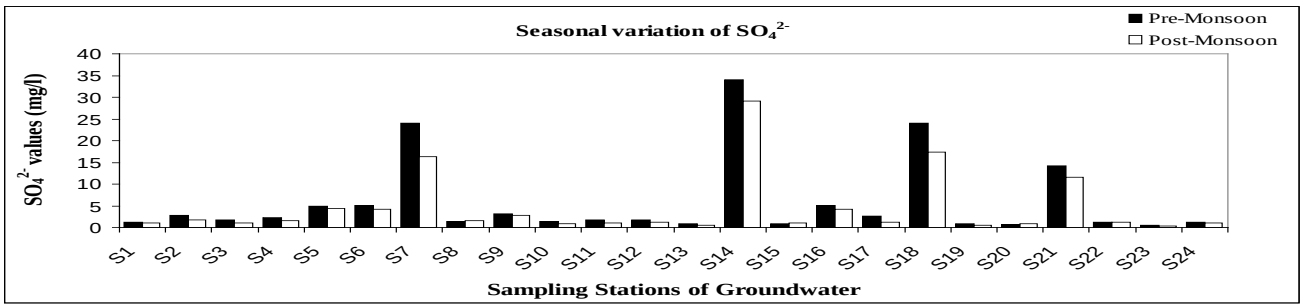
e

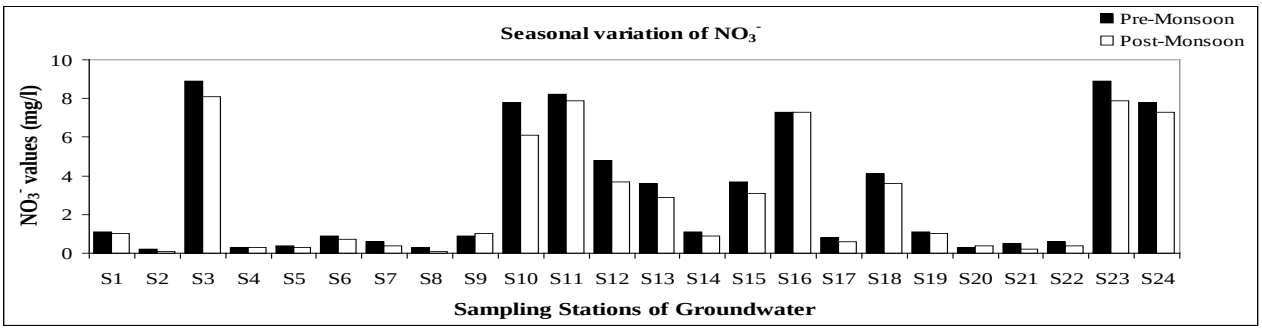

Seasonal variation of Cl-
Pre-Monsoon
Post-Monsoon
Cl- values (mg/l)
0 1000 2000 3000 4000 5000 6000
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24
Sampling Stations of Groundwater

f


Seasonal variation of HCO3-
Pre-Monsoon
Post-Monsoon
HCO3- values (mg/l)
0 100 200 300 400 500 600 700
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24
Sampling Stations of Groundwater

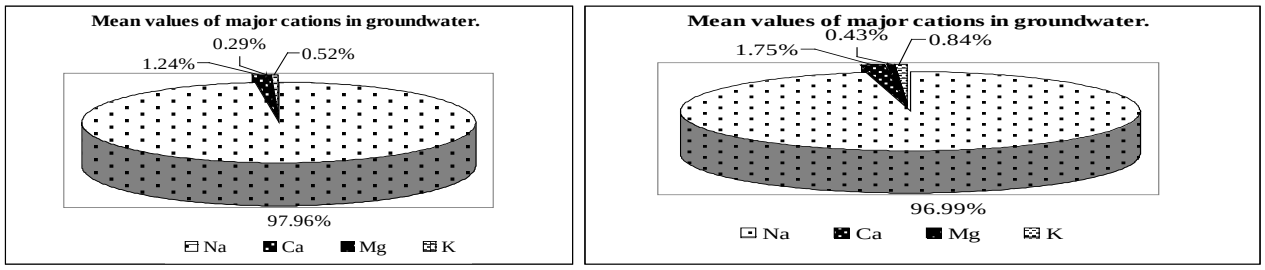
g


Seasonal variation of SO4 2-
Pre-Monsoon
Post-Monsoon
SO4 2- values (mg/l)
0 5 10 15 20 25 30 35 40
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24
Sampling Stations of Groundwater



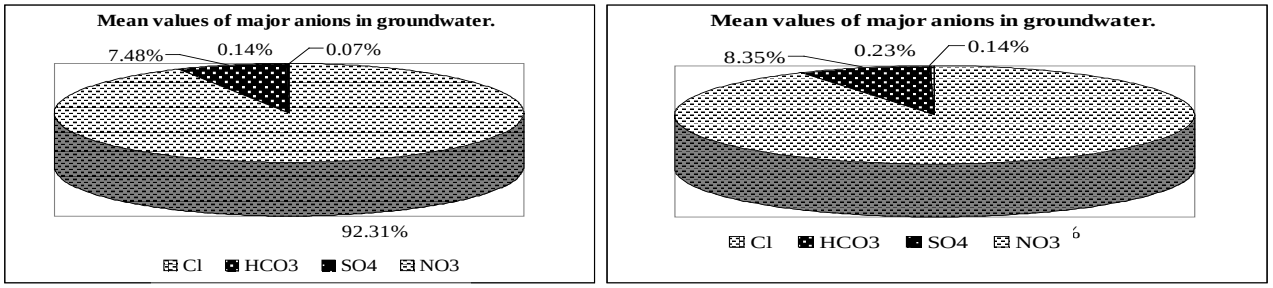

h

Figure 3. The seasonal variation of major chemical properties in G.W of the area.




(a) (b)

Figures 4 (a &b). Dominating of major cations and anions for pre-monsoon of Groundwater.




(a) (b)

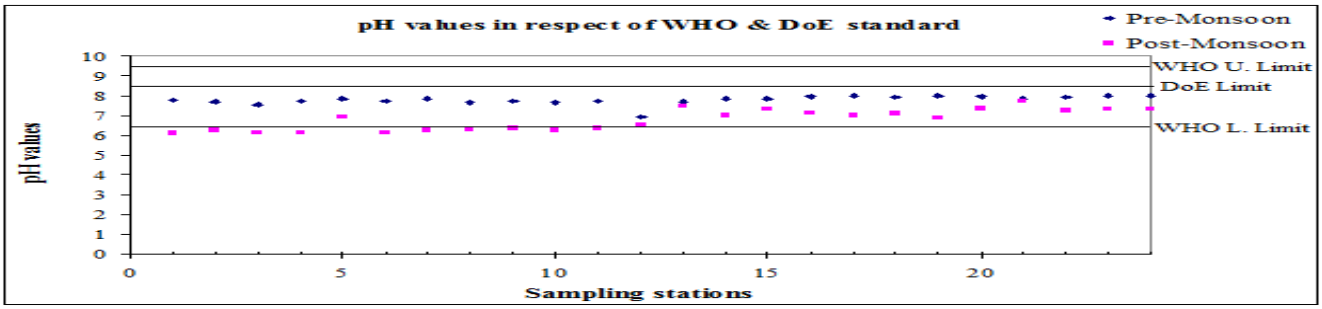
Figures 5 (a & b). Dominating of major cations and anions for post-monsoon of Groundwater.

### 3.3. Water Quality Measurement

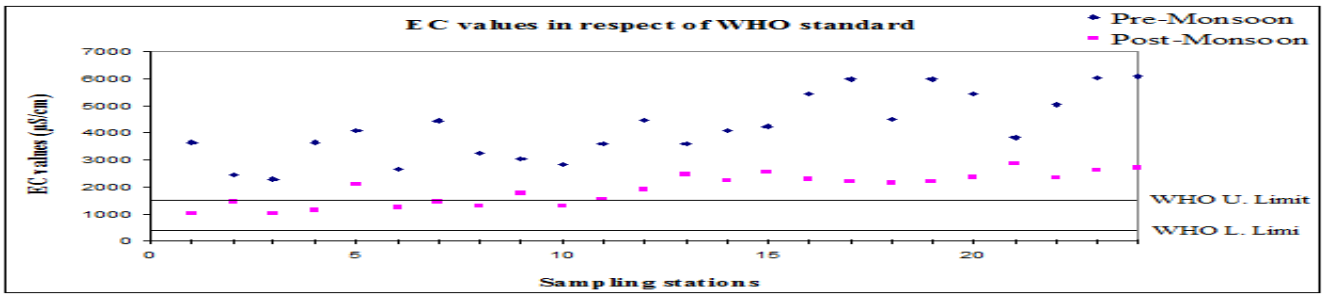
#### 3.3.1. Water Quality Based on Physical Parameters

The physical parameters such as color, taste, odor, temperature, electric conductivity (EC), total dissolved solids (TDS) and total hardness (TH) of groundwater samples are showed different characteristics and their quality are measured in respect of the WHO (2006) and DoE's (1997) standard for drinking purposes. The field taste result of color, taste and odor of the groundwater is unlike for drinking purpose in both season, but few are suitable for homely purpose after rainy season than before rainy seasons. The pH values range of 7.54 to 8.1 in pre-monsoon and 6.1 to 7.75 in post monsoon where most of the samples are between the WHO and DoE's permissible limit which indicated that most of the samples are suitable for both seasons and few samples are doubtful during post-monsoon period because their values are below the guideline (Figure. 6a). As the values of EC ranges from 2160 µS/cm to 3990 µS/cm in pre-monsoon and 860 µS/cm to 2240 µS/cm in post monsoon, which shows that all pre-monsoon and some post-monsoon samples are exceed the WHO and DOE limit and only few post-monsoon samples are within the recommended limit, which observed that groundwater in the area is unsuitable for drinking and domestic purposes in pre-monsoon period and few samples are suitable in post-monsoon (Figure 6b). Similar result also founds for TDS values ranges of 1849.2 mg/l to 2673.3 mg/ in pre-monsoon and 576.2

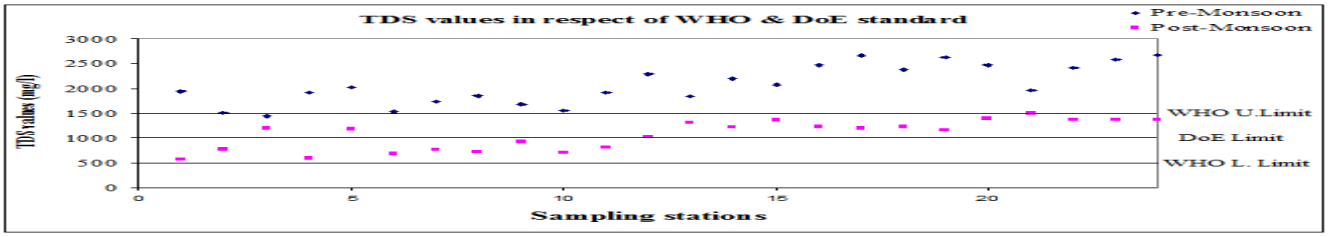
mg/l to 1500.8 mg/l in post monsoon period, while acceptable limit shows during post-monsoon period (Figure 6c). TH values ranges of 40.10 mg/l to 192.50 mg/l in pre-monsoon and 35.5 mg/l to 143.4 mg/l in post monsoon are quite below the WHO standard limit which indicates all groundwater samples of pre-monsoon and post monsoon period in the area are desirable for drinking and other purpose (Figure 6d).



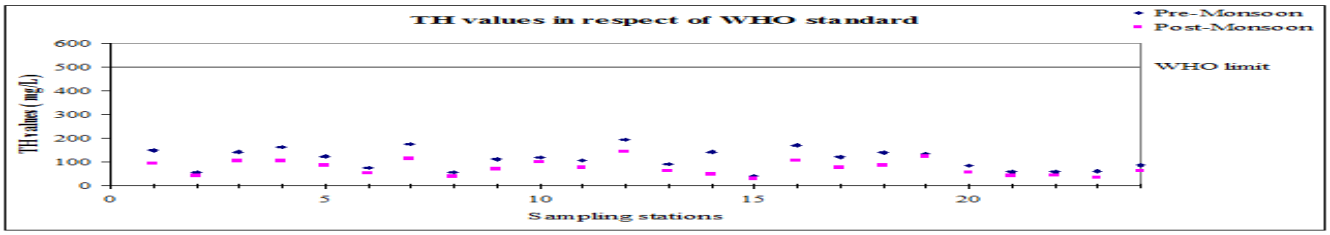

**(a)**




**(b)**




**(c)**



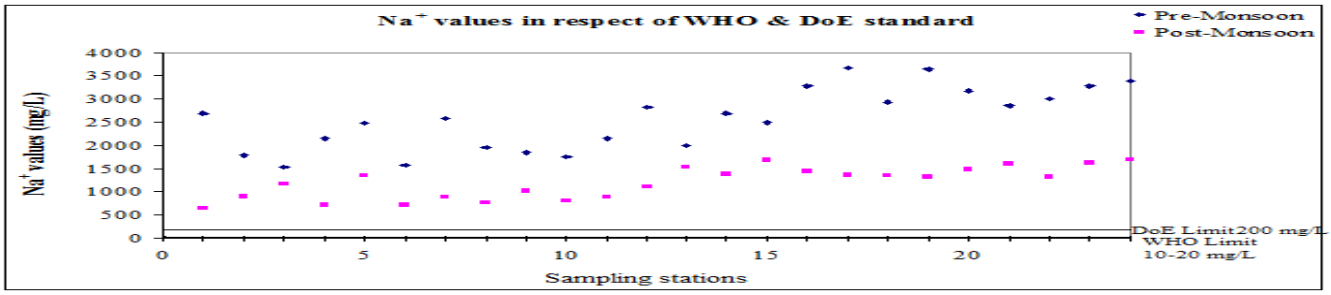

**(d)**

Figure 6: Water quality measured based on physical parameters in respect of WHO and DoE standard.

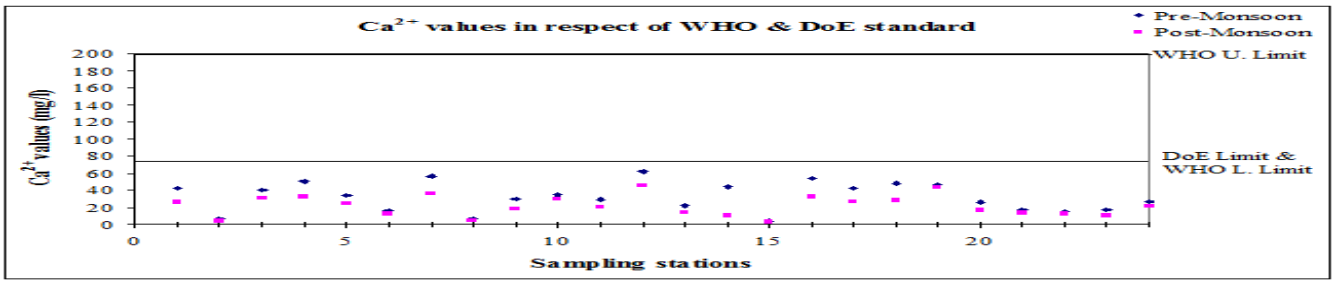
### 3.3.2. Water Quality Based on Chemical Parameters

The $Na^+$ concentrations of groundwater samples range of 1524.15 mg/l to 3666.70 mg/l for pre-monsoon and 630.99 mg/l to 1672.43 mg/l for post-monsoon which exceeded the WHO and DoE limit and indicate that groundwater of the area are unsuitable for any purposes (Figure 7a). The Calcium concentrations ranges of 62.12 mg/l to 4.01 mg/l for pre-monsoon and 45.59mg/l to 3.05mg/l in post-monsoon period which are below the lower limits of WHO & DoE recommend limit during both seasons and same result found for Magnesium concentrations. So, $Ca^{2+}$ and $Mg^{2+}$ concentrations in groundwater of the area are doubtful (Figure.7b & 7c). On

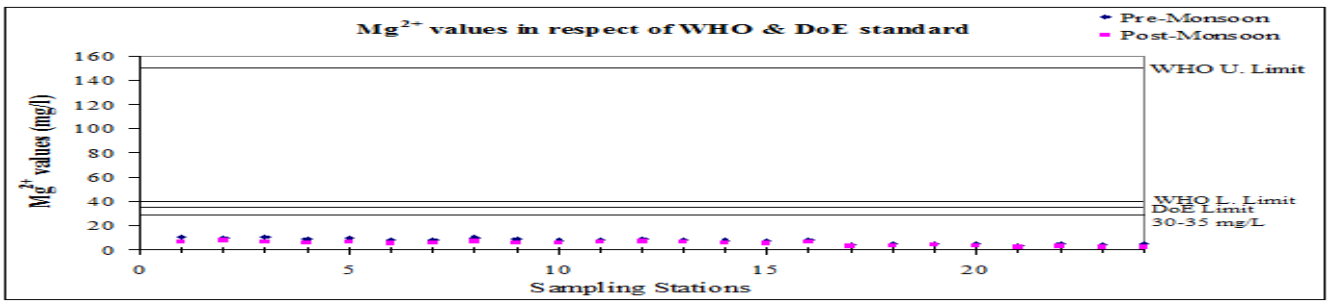
the other hand, the potassium concentrations ranges of 3.92 mg/l to 23.46 mg/l for pre-monsoon and 1.61 mg/l to 20.82 mg/l for post-monsoon are within the WHO & DoE recommend limit during both seasons which is announced that the water is suitable, while few samples are unsuitable and doubtful (Figure 7d). Chloride concentrations range of 2098.82 mg/l to 5598.74 mg/l for pre-monsoon and 929.58 mg/l to 2639.94 mg/l for post-monsoon are exceeded the WHO (2006) and DoE (1997) permissible limit that means the quality as chloride is unsuitable for drinking and other purpose during both seasons (Figure 7e). Bi-carbonate absorbency ranges of 100 mg/l to 650 mg/l for pre-monsoon and 100 mg/l to 300 mg/l for post-monsoon period which are within the recommend limit of WHO and DoE (Figure 7f). According to the analyzed result, concentration of sulfate and nitrate values are below the guideline of WHO and DoE during both seasons and it is advertised that the water quality in the area is doubtful for drinking and other purpose (Figure 7g & 7h).



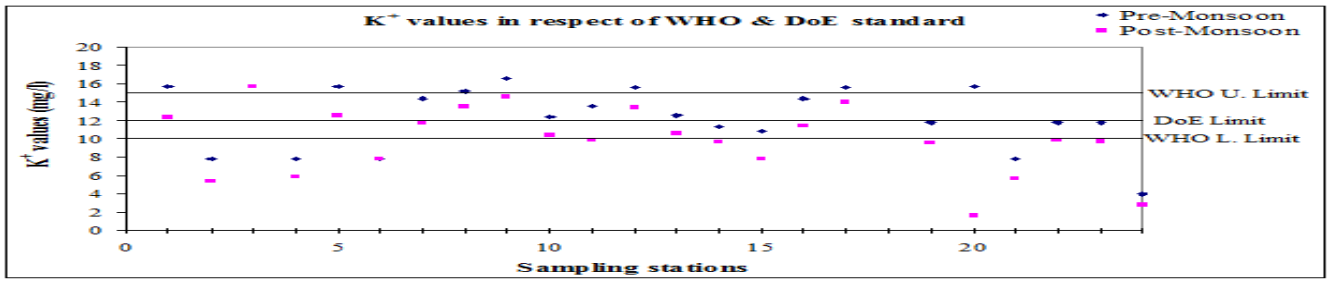

**(a)**



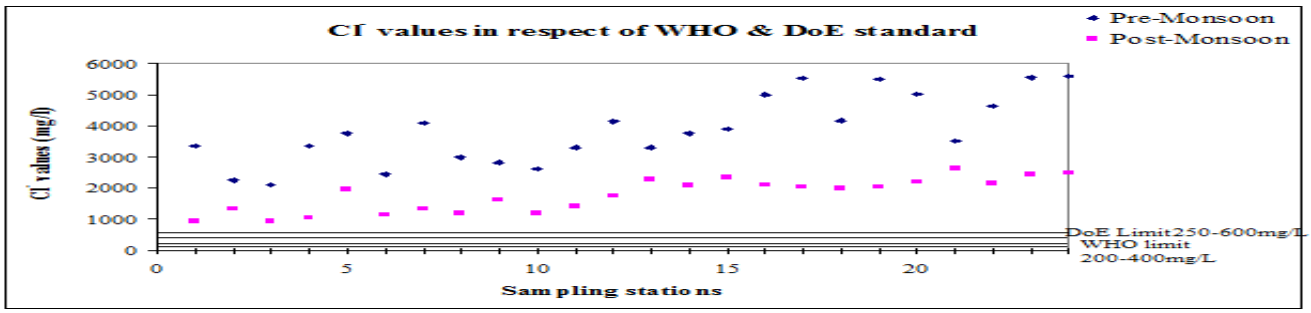

**(b)**



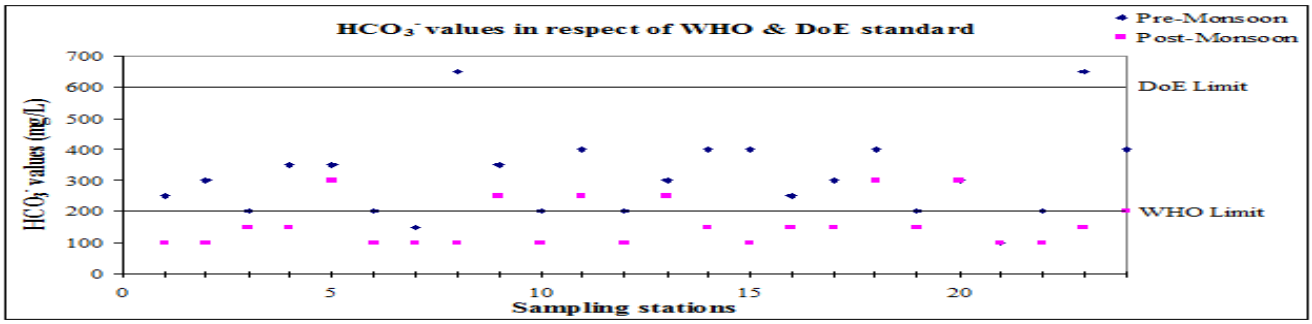

**(c)**



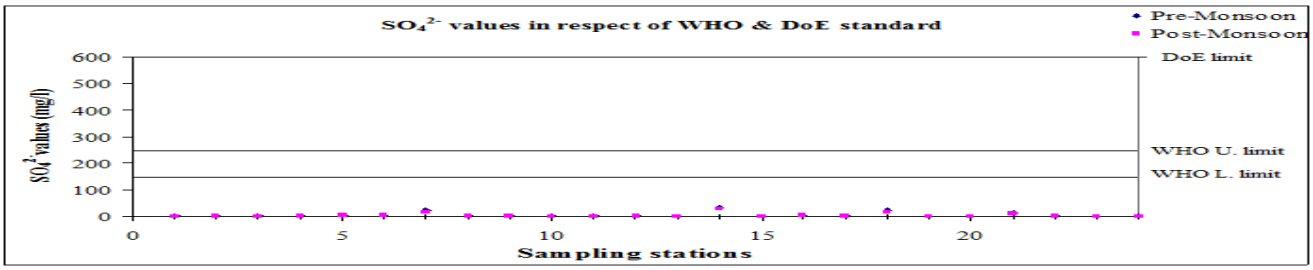

**(d**



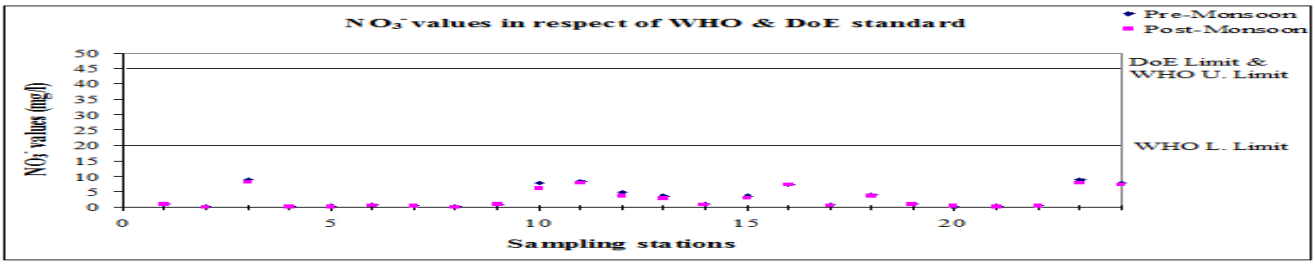

**(e)**




**(f)**




**(g)**




**(h)**

Figure 7. Water quality measured based on chemical parameters in respect of WHO and DoE standard.

### 3.3.3. Water Quality for Irrigation Purposes

There are some parameters which is very important to understand the suitability of ground water for irrigation purpose. Water classification based on the EC (Wilcox, 1995), 12 samples are doubtful and 12 samples are unsuitable in pre-monsoon, where 18 samples are permissible and 6 samples are doubtful in post-monsoon period (Table 1). Besides Rao (2005) also classified water into four categories and the results show that only one sample is high salinity type of water and 23 samples are very high salinity type of water in pre-monsoon period, while all samples (24) are high salinity water in post-monsoon period (Table 2). Water classification based on the % Na (Wilcox, 1995), all groundwater in the area is unsuitable for irrigation (Table 3). However water classification

based on SAR (Hounslow, 1995), all groundwater (24) samples are poor category for irrigation purposes (Table 4). From these study it is concluded that most of the groundwater in the area are unsuitable/ for irrigation purposes during both seasons.

Table 1. Water classification is based on EC for Irrigation (Wilcox, 1995).

| **Water class** | **EC (µS/cm)** | **No. of samples** | |
|---|---|---|---|
| | | **Pre-monsoon** | **Post-monsoon** |
| Excellent | <250 | 0 | 0 |
| Good | 250-750 | 0 | 0 |
| Permissible | 750-2000 | 0 | 18 |
| Doubtful | 2000-3000 | 12 | 6 |
| Unsuitable | >3000 | 12 | 0 |

Table 2. Water classification based on the EC in the study area (Rao, 2005)

| Category | Water quality | EC (us/cm) | No. of samples | |
|---|---|---|---|---|
| | | | Pre- monsoon | Post- monsoon |
| Group C1 | Low salinity water | 250 | 0 | 0 |
| Group C2 | Medium salinity water | 250 to 750 | 0 | 0 |
| Group C3 | High salinity water | 750 to 2250 | 1 | 24 |
| Group C4 | Very high salinity water | >2250 | 23 | 0 |

Table 3. Water classification is based on %Na for Irrigation (Wilcox, 1995).

| **Water class** | **Recommended** | **No. of samples** | |
|---|---|---|---|
| | **%Na** | **Pre-monsoon** | **Pre-monsoon** |
| Excellent | <20 | 0 | 0 |
| Good | 20-40 | 0 | 0 |
| Permissible | 40-60 | 0 | 0 |
| Doubtful | 60-80 | 0 | 0 |
| Unsuitable | >80 | 24 | 24 |

Table 4. Water classification is based on SAR for Irrigation (Hounslow, 1995).

| Water class | Recommended SAR | No. of samples | |
|---|---|---|---|
| | | Pre-monsoon | Pre-monsoon |
| Excellent | <10 | 0 | 0 |
| Good | 10 - 18 | 0 | 0 |
| Fair | 18 - 26 | 0 | 0 |
| Poor | >26 | 24 | 24 |

## 4. Conclusion

There is a lack of fresh water all over the world now. Bangladesh is no exception to it and coastal areas of Bangladesh are more vulnerable to salinity problem. Due to which the salinity of water in the coastal area is increasing. As a result water quality is deteriorating day by day. The evaluation of groundwater quality based on the physicochemical parameters concluded that all parameters are seasonally fluctuated, while most of the parameters remarkably decreased during post-monsoon period because most of the physicochemical properties concentrations in groundwater of the area are significantly decreasing during post-monsoon period due to monsoon rainwater dilution. Comparing of the most physicochemical properties of groundwater in the study area with WHO (2006) and DoE (1997) standard limits shows that some properties are acceptable in post-monsoon most of are unacceptable in pre-monsoon besides some are doubtful because their position is below the guideline. The groundwater quality for irrigation is compared based on electrical conductance (EC), per cent sodium (%Na) and sodium absorption ratio (SAR) shows that groundwater moderately unsuitable and poor quality for irrigation purposes, but little is suitable for irrigation in post-monsoon period according to EC values (Wilcox, 1995). So the study result concluded that most of the groundwater in the area is unsuitable or objectionable for drinking, domestic and irrigation purposes during both seasons. That is why the lives of the people of the coastal area are being severely damaged as well as the country's economy. The coastal people and the government need a lot of support to maintain the quality of groundwater. However some techniques such as prevention of seawater intrusion, rainwater harvesting, land pattern changing, decreasing pumping of tube well, making embankment can create a comparative better way to find suitable water for various purposes for future generation.

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# Usages and Impacts of Quinalphos in Commercial Aquaculture in Rajshahi, Bangladesh

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## Abstract

Fish farmers involved in commercial aquaculture in northwest Bangladesh is striving for ruthless efficiency of the system. In this process they have been selective poisoning the undesired species (!) by using quinalphos pesticides while keeping their desired species (Indian and Chinese major carps) seemingly unaffected. The study was conducted to know the impact of the use of quinalphos on zooplankton, aquatic insects and benthos population in commercial aquaculture ponds. To know the bioaccumulation phenomena, fish were collected pre and post-treatment and analyzed for residual content of quinalphos. Zooplankton, aquatic insects and benthos sample were collected and counted at pretreatment and after 1 day, 2 days, 5 days, 10 days, 15 days, 21 days and 28 days after the treatment. Quinalphos was found to be bioaccumulated in fish till 10 days after the use. Zooplankton were found to be impacted for short duration and were able to regenerate within 5 days of the use of quinalphos. Aquatic insects and benthos were also affected but the loss of insect diversity was observed till the end of the observation period.

**Keywords:** Quinalphos; Selective poisoning; Aquaculture; Bioaccumulation; Zooplankton; Aquatic insects.

## 1. Introduction

The activity of commercial aquaculture begins with complete wipeout of existing batch of left-over fish (that didn't come under catchment as live) and water insects from the pond using various chemicals (like starting with a clean sheet), which is followed by stocking of desired number of relatively large fish (Indian major carps of 0.5 kg to 1.5 kg in size)in northwest Bangladesh compared to the other parts of the country. In the process of transferring the live fish from the nursery pond to the stocking pond, undesired (!) small indigenous fish species like *Pseudambasis* sp., *Chanda* sp., *Glossogobius* sp. and *Puntius* sp. etc. also get transferred unintentionally by the farmers into the stocking pond. Since these small indigenous species can breed in ponds, within few months (especially after monsoon) they manage to multiply and populate the culture ponds of Indian major carps. Despite of the disparity of the size between these indigenous species and large Indian and Chinese major carps (more than 1.5 kg in size) in commercial ponds, farm owners view these small species as a challenge to the desired species that might face competition for food and space or at least get disturbed by these tiny fish. Some fish like *Chanda* sp. and *Pseudambasis* sp.(which usually present in large number) does keep biting and feeding on scales of carps, especially silver carps with their jaws that is armed with curved and conical teeth (Wahab, 2003) and thus make the carp fish scale less glossy, will reduce the price in the market if sold, apart from the risk of hampering the growth.On the other hand, *Glossogobius* sp. is a voracious feeder and almost feeds on everything namely decaying organic matter, protozoans, planktons, water insects, other fish and their eggs and larvae (Siddiqui *et al*., 2007). Thus *Glossogobius* sp. can create competition for feed supplied to the commercial aquaculture pond.

Quinalphos is a broad-spectrum organophosphate insecticide with contact and stomach action used against common pests like aphids, caterpillars, mealybugs, mites, bollworms, leafhoppers and borers of various crops and plants like wheat, sugarcane, peanut, sorghum, cotton, fiber-crops etc. has been in widespread use since 1970 (IUPAC, 2019). National Center for Biotechnology Information (NCBI) (2019) has categorized the toxicity of quinalphos as 'very toxic to aquatic life' and 'very toxic to aquatic life with long lasting effects'. Despite being labeled as very toxic, it has a wide range when comes to the toxicity to fish, that means for some fish tolerance level of quinalphos is way higher than others even within the same family of fish. For example, regarding quinalphos, 96 hour $LC_{50}$ value of silver barb (*Barbonymus gonionotus*) is 4.70 mg/l (Mostakim *et al*., 2014), of *Labeorohita* is 2.826 mg/l (Rathnamma and Nagaraju, 2013), of *Cyprinuscarpio* is 2.75 mg/l (Padmanabha *et al*., 2016), of Catlacatla is 2.91mg/l (Rajput, 2012), of *Cirrhinus mrigala* is 0.128mg/l (Nair *et al*., 2017) and of

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O*ncorhynchus mykiss* is 0.005 mg/l (IUPAC, 2019). Therefore, a given dose (depending on the dose itself) may be very toxic to one fish species while may not be harmful at all for another species. This phenomenon of quinalphos is exploited by the commercial fish farmers in northwest Bangladesh and quinalphos is being used as a weapon (selective poison) to kill and wipeout the undesired (!) fish species like *Chanda* sp., *Pseudambasis* sp. and *Glossogobius* sp. Though the author failed to find any reference for $LC_{50}$ value of *Pseudambasis* sp. and *Glossogobius* sp. for quinalphos but that is defiantly much lower than that of Indian major carps in commercial aquaculture ponds. The study was conducted to know the unintended consequences of use of quinalphos in commercial aquaculture ponds on fish, zooplankton, aquatic insects and benthos population.

## 2. Materials and Methods

The study was conducted in 3 different ponds (each of which were 2 to 3 acres in size) under commercial aquaculture located in Hatgodagari area of Pobaupazilla of Rajshahi. During the survey in the region the author came to know about this practice by the farmers. Therefore, farmers were communicated early to inform the author when they intend to use quinalphos in culture ponds. Accordingly, the author was present during the treatment in last week of November 2018. Total quantity of quinalphos pesticide was diluted in a big aluminum pot and then was broadcasted manually over the entire body of water of the pond. Based on the uses the doses were back calculated using the following formula: Concentration (mg/liter) = total amount of pure quinalphos (in mg) / volume of the water (of the pond in liter). Accordingly, the doses of quinalphos were found to be 0.02 mg/liter which is little less than $1/6^{th}$ of the (lowest of Indian major carps) 96-hour $LC_{50}$ value of *Cirrhinus mrigala* ($LC_{50}$ value is 0.128 mg/l). The study was repeated using similar doses of quinalphos (brand name Deviqueen 25 EC quinalphos marketed by 'The Limit Agroproducts Ltd') with two additional farmers at different times and each one/pond was considered as one replication. Sampling of zooplankton, aquatic insects and benthos was done just before the treatment and 1 day, 2 days, 5 days, 10 days, 15 days, 21 days and 28 days after the treatment. In addition, fish and water sample were also collected pretreatment and after 1 day, 2 days, 5 days and 10 days of the experiment for testing the residue level of quinalphos. For each sampling approximately one to one and half kg fish (*Labeo rohita*) were caught using cast net, put in a plastic bag and immediately transferred into the freezer. Water samples were collected from 18 inches below the surface of water level, at least from four different locations of the pond to make totaling of 1 liter. The water sample was put in non-transparent plastic bottle and immediately put into the freezer. Both the fish and water samples were coded with numbers and transferred to the 'Pesticide Analytical Laboratory' located in Entomology Division of Bangladesh Agricultural Research Institute (BARI). The lab then analyzed the sampleusing GCMS-MS machine (level of detection of organophosphate insecticides ranged from 0.003 to 0.009 mg/liter) for quinalphos residue and delivered the report.

### 2.1. Sampling of Zooplankton

Zooplankton sampling was done using a plankton net (specification- 200 US with 75 to 85 microns mesh size). The plankton net had a circular mouth/head fitted with a metal frame used as inlet. The opposite side of the opening has a tapering end fitted with a collection bottle. The net was towed through the pond water one feet below the surface for certain distance. Based on the traversed distance and radius of the opening end of the net, total volume of pond water sieved through the net was calculated. Then the collected zooplankton sample was taken into a plastic bottle. The sample in plastic bottle now represents the total volume of water sieved through the net. 5% formalin was added in the plastic bottle with sample for fixation and preservation of the planktons till they were taken to the lab, identified and counted using a Sedgewick-Rafter cell counter (Welch, 1948) under microscope. Based on the counting, volume of stock sample in plastic bottle and the total volume of water from where the sample was collected, zooplankton concentration (nos/liter of pond water) was calculated.

### 2.2. Sampling of Aquatic Insects

For collection of aquatic insects, a fine meshed net fitted with a square meter frame was towed for three meters along the edges of the pond. The collected insects were then transferred in a plastic bottle and 5% formalin was added for the preservation of the sample. Then it was taken to the lab where all insects were identified and counted.

### 2.3. Sampling of Benthos

For collection of Benthos, a metal scoop with 2.75-inch diameter and 1.5-inch depth was used to collect the soil sample from the bottom of the pond. Then the mud sample was taken into the lab sieved under running water to wash the mud out to isolate the benthos from the mud. The collected benthos was taken in petri-dish with some water and was identified and counted for each type under bright light.

## 3. Results and Discussion

Within two days of using of quinalphos *Glossogobius* sp. were found to be dead and floating on the pond water. Dead *Chanda* sp. was not found floating due to their body morphology but was confirmed by netting the water with fine meshed net. Farm owner confirmed very few live *Chanda* sp.was caught with fine meshed netting. The pond under commercial aquaculture where the study was conducted, was 3 acres in size (water body) with the depth of 4 feet water. In this large volume of water 1200 ml (25EC quinalphos) 'Deviqueen' was broadcasted over. Despite of the natural movement of the fish,due to the sheer volume of water there is no way this little quantity of quinalphos can be mixed homogeneously. Therefore, there was always inconsistency in density of quinalphos (some places it was denserthan other places) across the water body allowed some of the *Chanda* sp. individuals (tend to be huge in number) to survive and avoid complete extinction. That means every few months farmers are to repeat the treatment to keep control over *Chanda* sp. in aquaculture ponds. And farm owners positively verified that piece of information.

Figure 1. Dead *Glossogobius* sp. floating in the pond water treated with quinalphos (at 0.02 mg/liter water).

Farmers also mentioned that usually *Glossogobius* sp. individuals are more sensitive to this and almost all the individual are dead, and they would not show up until it is unintentionally reintroduced with new batch of desired species. Though the quinalphos concentration that was used in this experiment is less than one sixth of the 96 hour $LC_{50}$ value of *Cirrhinus mrigala*, still at least in one replication few *C. mrigala* individuals were found to be

dead, that is again due to the inconsistency of the dilution/distribution of the quinalphos in the pond water. However, in most cases where *C. mrigala* have not died, but they might have suffered some histopathological changes. Because, histopathological changes in fish were identified in many other studies when fish wereexposed to sub-lethal (one $10^{th}$ of 96-hour $LC_{50}$ concentration) concentration of quinalphos (Aswin, 2016).

Table 1. Quinalphos residue in water and fish at different points after the pond water treatment with quinalphos (at 0.02 mg/liter water)

| Duration of exposure | Sample | Level of residue (mg/kg) |
|---|---|---|
| Pretreatment | Water | Not detected |
| | Fish | Not detected |
| After 1 day | Water | Not detected |
| | Fish | 0.23 |
| After 2 days | Water | Not detected |
| | Fish | 0.16 |
| After 5 days | Water | Not detected |
| | Fish | 0.027 |
| After 10 days | Water | Not detected |
| | Fish | Not detected |

The residue analysis for quinalphos showed that within after 24 hours of the treatment the level of quinalphos in the water was below the level of detection range of the machine. In contrary quinalphos got bioaccumulated in fish (*Labeo rohita*) and the level of residue after 1 day, 2 days and 5 days were respectively 0.23 mg/kg, 0.16 mg/kg and 0.027 mg/kg (Table-1). At $10^{th}$ days after treatment quinalphos residue was nil in both the fish and water of the pond. This means there is health hazards if the fish are sold in the market within 5 days of quinalphos treatment. MRL values for quinalphos in food animals are recorded as 0.01mg/kg by European Commission (2019). Thinh *et al*. (2018) confirmed bioconcentration of quinalphos in fish muscle from a rice-fish experiment in Vietnam, where half-life of quinalphos was found to be 1.0 to 1.1 days for water and 1.3 to 1.9 days for *Cyprinus carpio*. The good news is that farm owners (from survey) in northwest Bangladesh never harvest and sold fish to the market after using the pesticide, not because they are very concerned about the public health but simply for economic reason. First of all, pesticides are expensive, if the fish are to be harvested and sold then why to use pesticide and the second thing is that since almost all commercial farmers of northwest Bangladesh sell fish in live condition, they understand that after pesticide treatment fish become weak and prone to death during the transportation (due to the stress related to harvesting and transportation) to the market would certainly loose its value.

The effect of quinalphos bioaccumulation in fish on other fish-eaters like heron, Indian cormorant, water snake (checkered keelback), monitor Lizard, who tend to live on these small species, was not possible to determine. Though these animals are abundant at the ponds where there is presence of small fish, but in this study when the dead *Glossogobius* sp. was floating no such predators found to be preying the dead fish. Hope that the predators were able to detect the risk that these dead fish and the bioaccumulation phenomena posed to them.

Table 2. Quality parameters of the experimental ponds

| Treatment pond | Water pH | Water temp ($^0$C) | Water turbidity (ntu) | Water electrical conductivity (µS/cm) | Organic carbon content of the pond bottom sludge (%) |
|---|---|---|---|---|---|
| quinalphos | 7.7±0.72 | 23.2±0.15 | 21.1±6.52 | 378±56.2 | 2.6±0.48 |

Quick degradation of quinalphos in the experimental pond water is justified by the quality parameters presented in Table 2. PPDB (2019) recorded aqueous hydrolysis DT50 (days) as 39 days in $20^0$C at pH 7, however the value reduced in both acidic and alkaline condition. Goncalves *et al.* (2006) recorded photolysis half life of quinalphos in water samples ranged between 11.6 to 19 hours, while nitrate ion accelerated the photodegradation, dissolve organic carbon slowed the process. The application method of quinalphos in the pond (broadcasted on the pond water) and the inconsistency in mixing with the water let the major portion of broadcasted quinalphos be on the water surface, exposed to bright sunlight subjected the quinalphos to be photolyzed quickly. *Bacillus* and *Pseudomonas* sp. from aqueous streams found to be effectively biodegraded 80% of quinalphos within 17 days in lab experiments by Dhanjal *et al.* (2014). *Ochrobactrum* sp. often present in pesticide contaminated soil, can use quinalphos as sole source of carbon and biodegrade it (Talwar *et al.*, 2014). Since the experimental pond is subject to feeding of pallet feed, high supplies of agrochemicals and intensive management (Belton *et al.*, 2011), it is more likely that presence of high nitrate ion and commonly occurring bacteria was available in the experimental pond (though not tested)contributed in quick biodegradation of the quinalphos in aqueous condition.

Zooplankton count showed that the zooplankton number reduced within one day of the treatment, it reached the lowest point after day-two of the treatment (Figure 2). After that the number started to increase and reached back to the previous level on day-five and continued to be almost static.

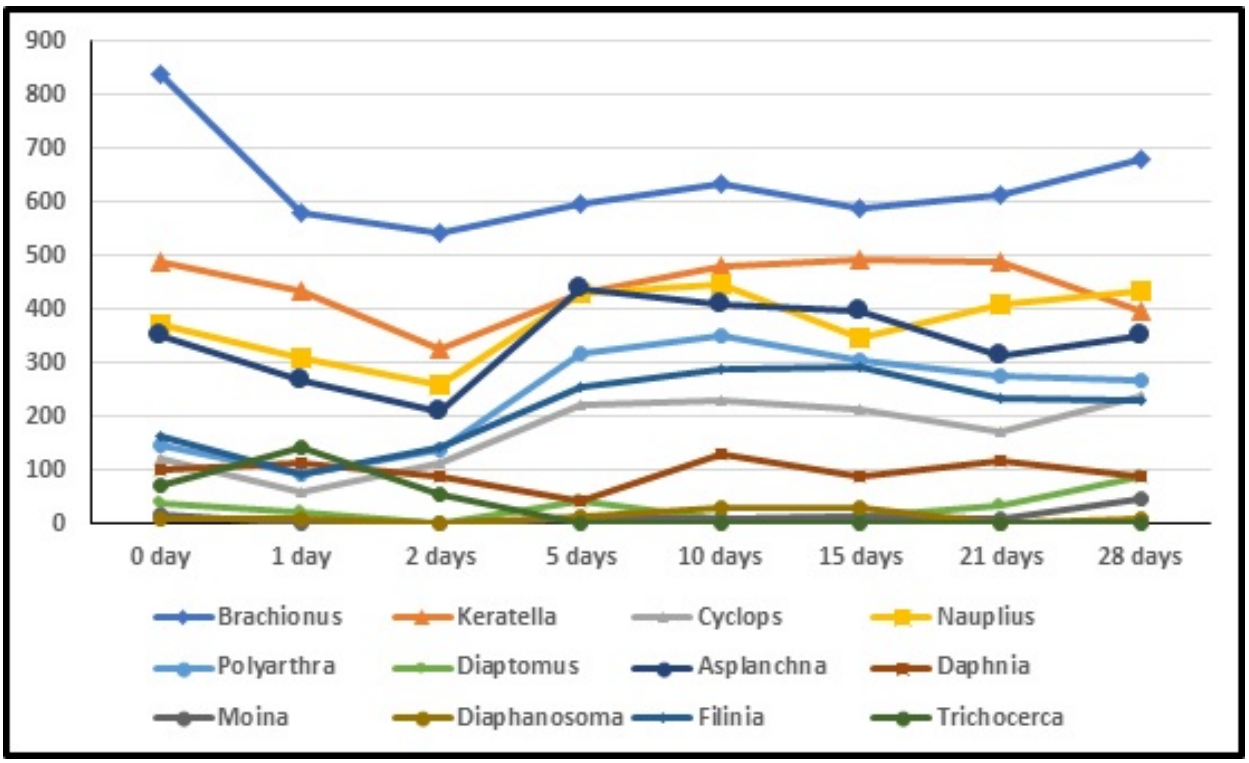


Figure 2. Zooplankton count (nos/liter) at various points of pond water treatment with quinalphos (at 0.02 mg/liter water).

Relatively short half-life (Table-1) of quinalphos in water meant that the effect of quinalphos on zooplankton population showed up early (day-1 and 2) in the observation period. Then they were able to regenerate to the normal level. Gajbhiye *et al.* (2010) reported rapid degradation followed by short residual life of quinalphos in environmental conditions. 48-hours $EC_{50}$ of *Daphnia magna* for quinalphos was reported to be 0.00066 mg/l by IUPAC (2019). Despite of having the higher concentration (0.02mg/l), the inconsistency in quinalphos dilution in treatment pond (due to the large volume of water) in combination with slow mobility of the zooplanktonswere again the reasons for not wiping out the total zooplankton population.

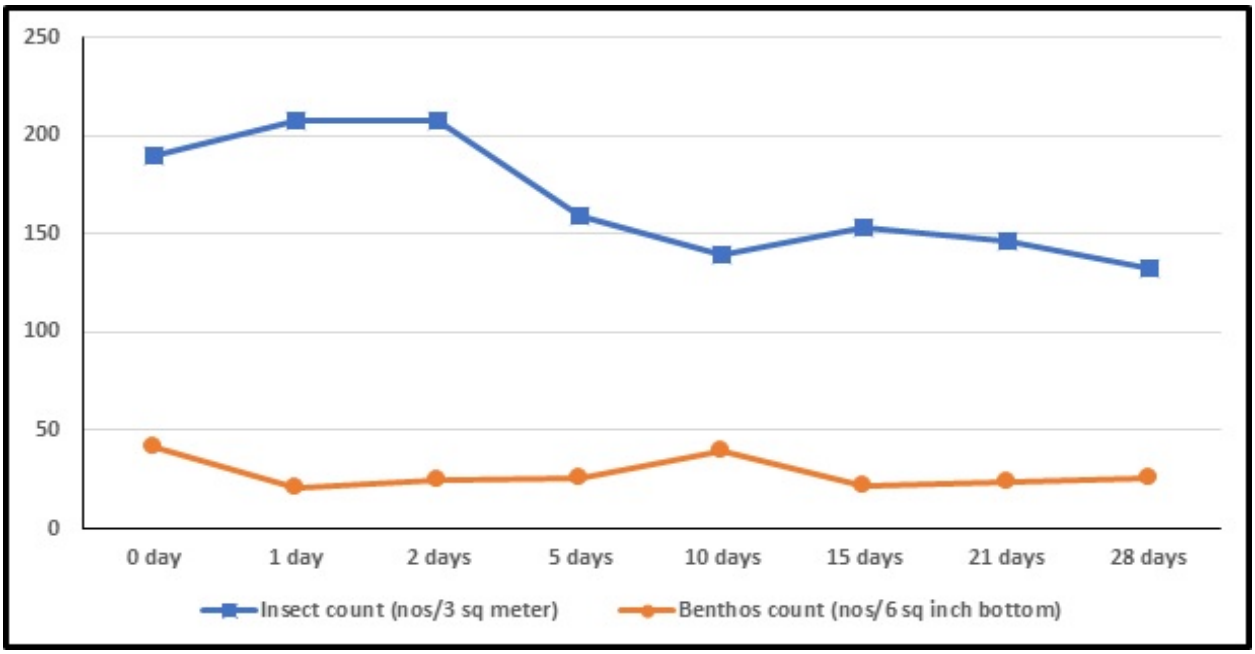


Figure 3. Aquatic insect and benthos count at various points of pond water treatment with quinalphos (at 0.02 mg/liter water).

Aquatic insect count showed that the number got down moderately around 5$^{th}$ days after the treatment and then 10$^{th}$ day onwards remain almost static (Figure 3). On the other hand, benthos count showed that the number got down moderately one day after the treatment and slight increased and almost continued to stay the same till the end of the observation period, 28 days except increased number was observed (like a spike), on the 10$^{th}$ day. The author has no logical explanation for this spike except the possibility of sampling error.

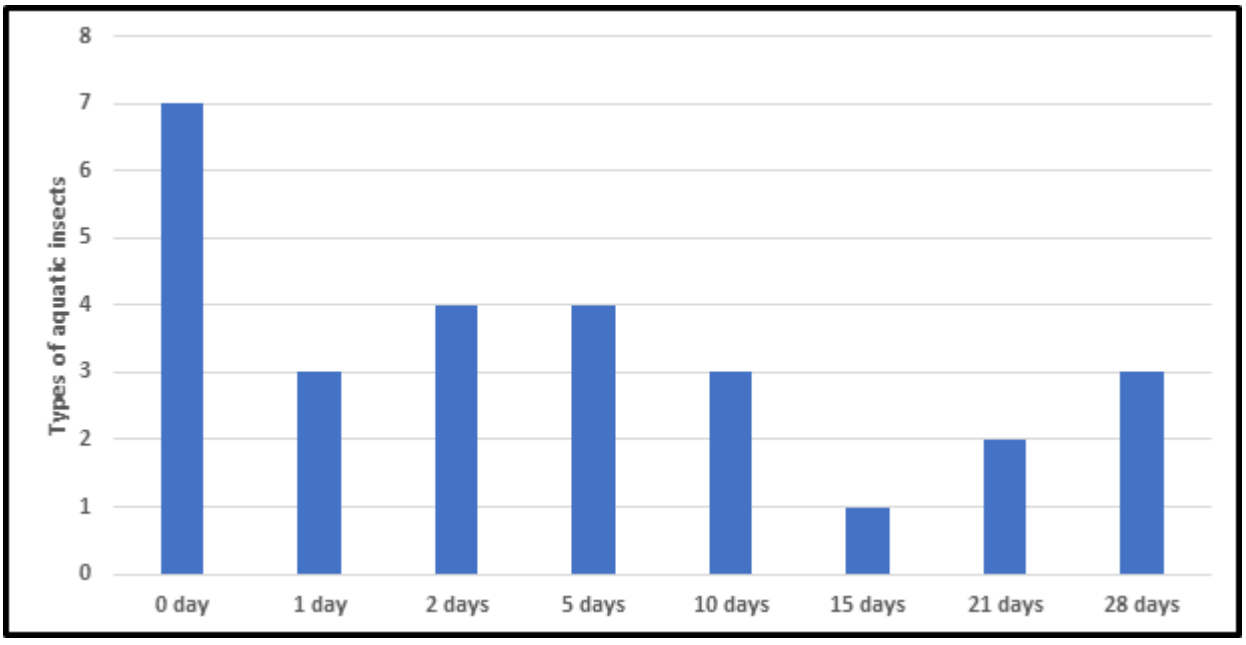


Figure 4. Water insect diversity at various points of pond water treatment with quinalphos (at 0.02 mg/liter water)

The diversity of the aquatic insect was greatly affected (Figure 4) than the total counts of insects (Figure 2) due to the quinalphos treatment in pond water. One day after the treatment insect types found to be three as opposed to the seven types that was recorded at pre-treatment. Of the aquatic insects may fly and *Gerris* sp. were not found

after the fifth day, *Ranatra* sp. and dragon fly didn't show up after the 10th day of the use of quinalphos. Water scavenger was missing after pretreatment observation and showed up again at the very end of the observation period. The number of backswimmer and boatman declined but recovered slowly. The insect diversity counts never recovered to the pretreatment level till the end of the observation period. The non-recovery phenomenon may be attributed to the season (month of December) which may not be the primetime for many aquatic insects to reproduce in Bangladesh (Nasiruddin *et al*., 2014).

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# Adaptation Strategies of GOs and NGOs for Flood Management in the Teesta Floodplain Area in Rangpur District of Bangladesh

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## Abstract

In the Teesta river basin area, people suffer and fight against flood almost every year. Flood affected people get support from GOs, NGOs and other private organizations in pre, during and post flooding period. But these supports are not sufficient for them and they fall in long term poverty trap which refers to the incapability of achieving a minimum standard of living. So this study presents various adaptation strategies of GOs and NGOs, and suggests some recommendations to rapid recover from flood disaster in the research area. The study area is located in flood prone region of the Teesta river basin in Rangpur district of Bangladesh. Lakshmitari union of Gangachara upazila and Kaunia Balapara union of Kaunia upazila have been selected for this study. Primary and secondary data have been collected to fulfill the research objectives. The research findings indicate that flood is occurred every year in the study area. To minimize the damages of flood, GOs and NGOs take various steps. These steps awareness build-up of people, building embankment and shelter center, operate rescue operation, giving relief and emergency treatment, etc. But these activities are not sufficient fully to reduce the impacts of flood. So this study recommends some policies like building embankment in total eroded area, develop early warning system, increase the number of flood shelter center, etc. to minimize the damage of flood and improve the life standard of flood affected people in the study area.

**Keywords:** Flood; Adaptation Strategies; GOs; NGOs; Teesta Floodplain.

## 1. Introduction

Bangladesh lies approximately between 20°30' and 26°40' north latitude and 88°03' and 92°40' east longitude. It is one of the biggest active deltas in the world with an area about 147570 sq. km. The country is under sub-tropical monsoon climate, annual average precipitation is 2300 mm, varying from 1200 mm in the north-west to over 5000 mm in the north-east. India borders the country in west, north and most part of east. The Bay of Bengal is in the south, Myanmar borders part of the south-eastern area. It has 405 rivers including 57 transboundary rivers, among them 54 originated from India (BWDB, 2011). Since Bangladesh achieved independence in 1971, GDP has more than tripled in real terms, food protection has increased three fold, the population growth rate has declined from around 2.9% per annum in 1974 to 1.4% in 2006 and the country is largely food secure. Over the last 20 years, growth has accelerated and the country is on track to become a middle income country by 2021 when it will celebrate its 50 years of independence (MoEF, 2009). Despite these successes, the country is highly vulnerable to natural hazards like catastrophic cyclones, tornadoes, storm surges, droughts, floods, earthquakes, riverbank erosion, and landslides. Floods are the most common natural hazard affecting Bangladesh, with about 20 million people present in zones subject to flooding (Gemenne *et al*., 2011). Bangladesh is mostly flat except some hilly part in the southeast and the northeast and about all rivers are come in our country in mature stage. This country was formed due to sedimentation of the large river systems. For these reason some 30 to 35% of the total land surface of the country is flooded every year during wet monsoon (Milliman *et al*., 1989). Flooding is one such water related environmental problem magnitude of which is very much dependent on land-use practices in the watershed of each rivers or streams (Khalequzzaman, 2000).

According to Nishat, 2004, an area goes under and remains under water for some times, it is inundation. When inundation causes damage to property and crops, disrupts communication and brings harmful effects to human beings as well as flora and fauna, we call it flood. So it is said that inundation and damage are together considered as flood.

When water flow of the river or other channel exceeds certain stage, spreads the bank area or adjoining high land and damages the environment and man-made things this situation is enumerated as flood (Rumana, 2020).

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The Teesta is one of the longest rivers and 4th largest trans-national river in Bangladesh. This river makes a total run of about 170 km from its entrance into Bangladesh to the Kamargani mauza of Gaibandha where it merges with Brahmaputra river. The Teesta river located in the north-western part of the country which includes the present districts of Nilphamari, Lalmonirhat, Rangpur, Kurigram and Gaibandha.

The Teesta originated from the Teesta source Glacier-Pauhunri Glacier, Teesta kangse near Khangchung lake (27°59' N; 38°48' E at an elevation of 7128/2173 m.). Out of its 250 miles about 100 miles (170 km.) lies in Bangladesh (Hanif, 1995).The Teesta flood plain covers nearly 14 % of the total cultivated area of Bangladesh and provides livelihood opportunities directly to approximately 7.3 % of the population or 9.15 million people in five districts of Rangpur division (BBS, 2012). In spite of decreasing the monga situation which was created an immense bar to reach an expected level of development, people of northern Bangladesh cannot overcome from the damage of flood or river bank erosion. Almost every year flood occurs in this region and many people fall in vulnerable situation in that time which affects seriously on their livelihood.

## 2. Selection of the Study Area

The study has been conducted in two unions (Lakshmitari and Kaunia Balapara) of Gangachara and Kauniaupazila, respectively of Rangpur district. Lakshmitari union consists by 9 mauzas and more flood affected mauzas are Sankardaha, Ichli, Char Isorkul and Joyramojha. So mentioned four mauzas have been selected as the study area. On the other hand Kaunia Balapara union has 21 mauzas and more vulnerable mauzas are Arazi Harishwar, Gadai, Panjarbhanga and Nijpara. So these mauzas have been selected as the study area. Lakshmitari and Kaunia Balapara unions are highly flood prone area of both upazilas. These areas are also affected by river bank erosion. That is why these areas have been selected as the study area.

## 3. Materials and Method

### 3.1. Sampling Design and Sample Size

In this research purposive sampling and simple random sampling have been used to select study area and sample size. Gangachara and Kaunia upazila of Rangpur district have been selected purposively. Gangachara upazila has 10 unions, among them one union (Lakshmitari) has been selected purposively. On the other hand Kaunia upazila consists by 6 unions. One union (Kaunia Balapara) out of 6 unions has also been selected purposively. At last simple random sampling techniques has been applied to get proportionate of household number for surveying and collecting data and information.

To determine the sample size, method of Krejcie and Morgan (1970) has been applied. As per the determining procedure of them, 361 households out of 6124 have been selected as sample size. Out of 361 sample size 156 from Lakshmitari union and 205 from Kaunia Balapara union have been taken for surveying and collecting data.

Table 1. Guide to minimum sample size (95% confidence level, +/- 5% margin of error)

| Population size | Sample size | Population size | Sample size |
|---|---|---|---|
| 10 | 10 | 550 | 226 |
| 20 | 19 | 600 | 234 |
| 40 | 36 | 700 | 248 |
| 50 | 44 | 800 | 260 |
| 75 | 63 | 900 | 269 |
| 100 | 80 | 1000 | 278 |
| 150 | 108 | 1200 | 291 |
| 200 | 132 | 1300 | 297 |
| 250 | 152 | 1500 | 306 |
| 300 | 169 | 3000 | 341 |
| 350 | 184 | 6000 | 361 |
| 400 | 196 | 9000 | 368 |
| 450 | 207 | 50000 | 381 |
| 500 | 217 | 100000+ | 385 |

Source: Krejcie and Morgan, 1970

To determine the sample size, method of Krejcie and Morgan (1970) was applied by following process:

Household number of selected villages at Lakshmitari and Kaunia Balapara are 2652+3472 = 6124.

Total population size = 6124 (Population size is near to 6000, so sample size is 361 which is mentioned in table-1).

Sample fraction = 361÷ 6124 = 0.059

Sample size = 2652 × 0.059 = 156.468 (156) and

3472 × 0.059 = 204.848 (205)

Total sample size = 361 household

### 3.2. Data Collection, Analysis and Interpretation

Primary and secondary data have been used in current study to fulfill research objectives. Primary data has been collected from reconnaissance survey, questionnaire survey, interview with key informant and field observation. Secondary data has been collected from different government offices of Gangachara, Kaunia upazila and Rangpur district. Secondary data has also been collected from different books, journals, articles, statistical reports, official documents, unpublished M.S and Ph.D. reports, newspapers, internet, etc. The collected data have been processed and analyzed through SPSS software (version 16.0).For data analysis and interpretation different type of statistical methods such as chart, tabulation, percentage, average and graphic presentation have been used.

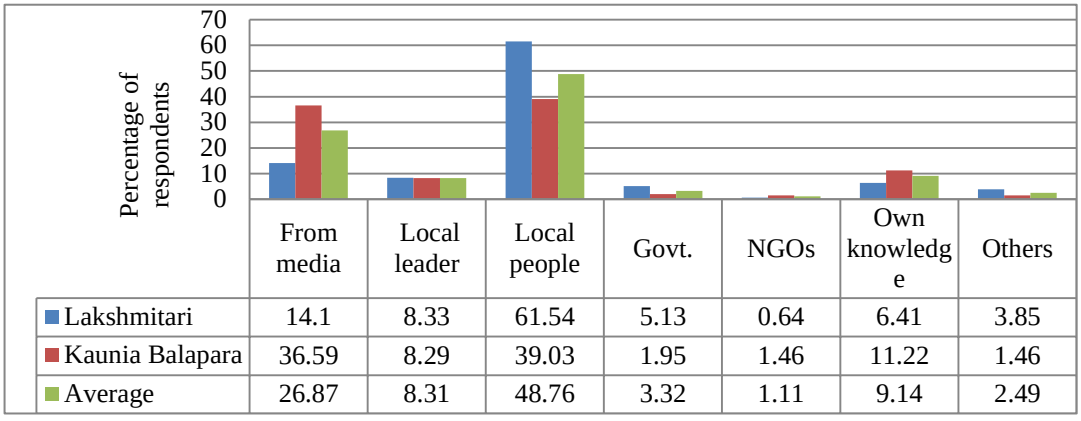
## 4. Result and Discussion

Almost all people of the study area are affected partly or fully by flood and sometime river bank erosion in every flooding year. To reduce the damage of flood and adapt with it GOs and NGOs take various steps in the study area like announce by media and leaflet/poster, building embankment, operate rescue operation, giving relief and emergency treatment, etc. Strategies of GOs and NGOs have been described on the basis of pre, during, and post flood period below.

### 4.1. Adaptation Strategies in Pre Flood Period

#### 4.1.1. Sources of Awareness Build-up of People to Get Rid from different Flooding Problems

Government and NGOs worker, media, local leader, local people, etc. are main sources of awareness build-up of people. The Figure-1 expresses that at Lakshmitari only 14.10 % respondents raised their awareness by media, this is lower than Kaunia Balapara where 36.59 % respondents said that they build-up their awareness from media. On an average 8.31 % respondents increased their consciousness from local leader. Maximum respondents (48.76 %) in both study unions mentioned the local people as a source of awareness build-up. Only 5.13 % respondents said about Govt. help to get rid from many types of flooding problems at Lakshmitari which is higher than Kaunia Balapara (1.95 %). On an average 1.11 % respondents told about NGOs as a source of increasing awareness.




| | From media | Local leader | Local people | Govt. | NGOs | Own knowledge | Others |
|---|---|---|---|---|---|---|---|
| Lakshmitari | 14.1 | 8.33 | 61.54 | 5.13 | 0.64 | 6.41 | 3.85 |
| Kaunia Balapara | 36.59 | 8.29 | 39.03 | 1.95 | 1.46 | 11.22 | 1.46 |
| Average | 26.87 | 8.31 | 48.76 | 3.32 | 1.11 | 9.14 | 2.49 |

Source: Field Survey, 2017

Figure: 1. Sources of awareness build-up of people to get rid from different flooding problems

### 4.1.2. List of Distributed Leaflet/Poster in 2017 Flood

Bangladesh government takes different steps like media, leaflet/poster, etc. to increase the awareness of people for protecting their assets from any kind of disaster. The Table-2 focuses the distributed leaflet/poster for protecting livestock and poultry at Gangachara and Kaunia upazila. Both upazilas were affected by flood in 2017. So these leaflets/posters were supplied in that areas to build-up the awareness of people to protect their livestock and poultry from flood hazard.

Table 2. List of distributed leaflet/poster in 2017 flood

| Name of upazila | Name of leaflet/poster | No. of supplied leaflet/poster |
|---|---|---|
| Gangachara | Leaflet for protection livestock and poultry of farmer during and post flood | 125 |
| Kaunia | Leaflet for protection livestock and poultry of farmer during and post flood | 125 |

Source: District Livestock Office, Rangpur, 2019

Government considered that the minimizing flood loss through non-structural measures is very important. Early warning on flood can save life and property. With this end in view, Flood Forecasting and Warning System (FFWS) was established in 1972 with 10 Flood Monitoring Stations on the major river systems. It now covers the entire country with 85 Flood Monitoring Stations and provides real time flood information with early warning for lead-time of 24 and 48 hours. FFWS currently help the government, the disaster managers and the communities living in the flood prone areas in matters of flood preparedness, preparation of emergency mitigation plan, agricultural planning and rehabilitations, etc. (WMO/GWP, 2003).

### 4.1.3. Number of Flood Shelter Center

On an average 38.50 % respondent expressed that flood shelter center is situated in their locality. Maximum respondents in both study areas said that one flood shelter center is located in their nearest locality. The table-3 reveals that at Lakshmitari 48.08 % respondents told about one flood shelter center and at Kaunia Balapara 24.88 % respondents said one flood shelter center is situated. Only 3.20 % and 3.90 % respondents said about two flood shelter center at Lakshmitari and at Kaunia Balapara, respectively.

Table 3. Number of flood shelter center

| Number | Number of respondents (%) | | |
|---|---|---|---|
| | Lakshmitari | Kaunia Balapara | Average |
| 1 | 48.08 | 24.88 | 34.90 |
| 2 | 3.20 | 3.90 | 3.60 |
| 3 | - | - | - |
| **Sub total** | **51.28** | **28.78** | **38.50** |
| No of flood shelter center | 48.72 | 71.22 | 61.50 |
| Total | 100 | 100 | 100 |

Source: Field Survey, 2017

### 4.1.4. Number of Flood Shelter Center at Gangachara and Kaunia Upazila-2017

Flood is happened almost every year at Gangachara and Kaunia upazila in Rangpur district. That's why flood shelter center has been made by government and non-government organizations in both upazilas. Besides some safety structures have been situated, where people take shelter during flood. At Gangachara 02 and 04 number of flood shelter center have been built by government and non-government organizations (Table-4). On the other side at Kaunia, number of 01 flood shelter center has been made by government and number of 08 flood shelter centers by non-government organization.

Table 4. Number of flood shelter center at Gangachara and Kaunia upazila- 2017

| Type of shelter center | No. of flood shelter center | |
|---|---|---|
| | *Gangachara | **Kaunia |
| Government | 2 | 1 |
| Non-government | 4 | 8 |
| Safety structure for shelter | 10 | - |

Source: *PIO, Gangachara Upazila, Rangpur, 2019/ **PIO, Kaunia Upazila, Rangpur, 2019

### 4.1.5. Embankment in the Teesta River in the Study Area-2017

Building embankment is a long term flood management system. To minimize the flood hazard, Bangladesh government has been built embankment in some places in the bank of Teesta river at Gangachara and Kaunia upazila. The Table-5 reveals that at Gangachara the length of embankment is 35 km whereas at Kaunia this length is 9.5 km. In the study area embankment has been built in some areas by government as a long term flood management activities. But embankment is not built in total erosion affected area of the Teesta river at Gangachara and Kaunia upazila. For this reason people of this area are not safe from flood and river bank erosion. They face and fight against flood and river bank erosion almost every year.

Table 5. Embankment in the Teesta river in the study area-2017

| Upazila | Length of embankment (Km) |
|---|---|
| *Gangachara | 35 |
| **Kaunia | 9.5 |

Source: *PIO, Gangachara Upazila, Rangpur, 2019 **PIO, Kaunia Upazila, Rangpur, 2019

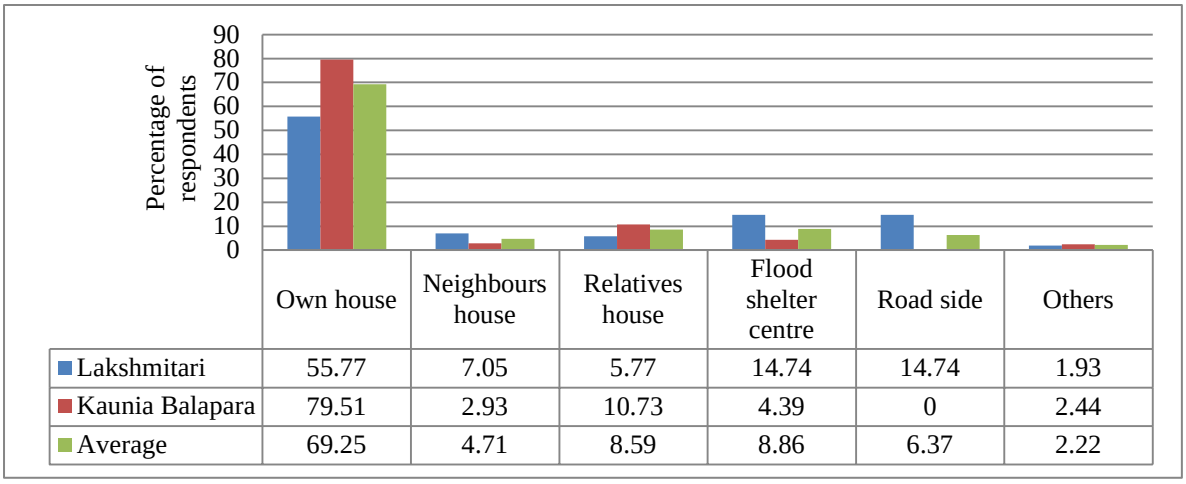
Structural solutions call for the engineering of structures such as embankments along rivers, dams, drains, reservoirs, and other structures designed to control the natural flow of rivers. Structural solutions treat the problem section of a river basin in isolation (Rasid and Paul, 1987).

### 4.2. Adaptation Strategies during Flood Period

### 4.2.1. Living Place of People during Flood-2017

Flood affected people of the study area lived in different places for the safety of their family in 2017 flood. The Figure-2 presents that more than two third (69.25 %) of total respondents lived in their own house in flooding time. Many houses of those respondents were affected by the flood water. In that case they raised their household furniture and lived where. On the other side the large number of respondents could not live in their own house due to serious condition of flood. They left their houses and went in other places with their family. These places were neighbors or relatives house, flood shelter center, road side, etc.

It is estimated that at least 1 million people are displaced due to flood and riverbank erosion in the country every year (Elahi, 1992).




| | Own house | Neighbours house | Relatives house | Flood shelter centre | Road side | Others |
|---|---|---|---|---|---|---|
| Lakshmitari | 55.77 | 7.05 | 5.77 | 14.74 | 14.74 | 1.93 |
| Kaunia Balapara | 79.51 | 2.93 | 10.73 | 4.39 | 0 | 2.44 |
| Average | 69.25 | 4.71 | 8.59 | 8.86 | 6.37 | 2.22 |

Source: Field Survey, 2017

Figure: 2 Living place of people during flood-2017

### 4.2.2. Number of People taking Shelter during Flood-2017

During flood in 2017, people of the Gangachara and Kaunia upazila took shelter in deferent places. At Gangachara number of 3200, 27000 and 25000 people stayed in GOs and NGOs shelter center, own house and road side or embankment respectively (Table-6). On the other hand at Kaunia number of 6000 people took shelter at GOs and NGOs shelter center which number was almost doubled than Gangachara upazila. Again number of 7000, 12000 and 4500 people stayed in own house, road side or embankment and temporary shelter camp respectively at kaunia upazila (Table-6).

Table 6. Number of people taking shelter during flood-2017

| Upazila | Date of report | No. of people in sheltered place | | | |
|---|---|---|---|---|---|
| | | GOs and NGOs shelter center | Own house | Road side and embankment | Temporary shelter camp |
| *Gangachara | 13.9.17 | 3200 | 27000 | 25000 | - |
| **Kaunia | 8.10.17 | 6000 | 7000 | 12500 | 4500 |

* Source: PIO, GangacharaUpazila, Rangpur, 2019/ **PIO, Kaunia Upazila, Rangpur, 2019

Flood creates the vulnerable situation in the affected area. Many people cannot stay in their own house. They take shelter in different places with their family and they face various types of problems due to flood.

### 4.2.3. Help of Rescue Operation Team-2017

GOs, NGOs, university/college, etc. work in the flood affected area as rescue operation team. In the study area, Union Parishad, Bangladesh Army, BNCC, etc. are active to help flood affected people during flood as the Govt. organizations. Different type of NGOs rescue flood affected people. Besides people get rid from local organizations, local leader and other sources during flood. The table-7 shows that majority of the respondents said that, rescue operation team helped in their locality during flood in 2017. At Lakshmitaria half of respondents (50.64 %) got rid from Govt. organizations which are higher than Kaunia Balapara (26.34 %). 12.18 % respondents said that, they got help from different NGOs at Lakshmitari whereas different NGOs helped to 4.39 % respondents at Kaunia Balapara. Except these on an average 1.94 % respondents were rescued by other organizations during flood in the study area. It is mentionable that maximum respondents got rid from different Govt. organizations, NGOs and other organizations at Lakshmitari than Kaunia Balapara. So it can be said that

because of serious condition of flood, people of Lakshmitari union got more help from these organizations than Kaunia Balapara.

Table 7. Help of rescue operation team-2017

| Category | | Number of respondents (%) | | |
|---|---|---|---|---|
| | | Lakshmitari | Kaunia Balapara | Average |
| Yes | Govt. | 50.64 | 26.34 | 36.84 |
| | NGOs | 12.18 | 4.39 | 7.76 |
| | University/college | - | - | - |
| | Others | 2.56 | 1.46 | 1.94 |
| No | | 34.62 | 67.81 | 53.46 |
| Total | | 100 | 100 | 100 |

Source: Field Survey, 2017

### 4.2.4. Rescue Operation by Bangladesh Army in the Study Area-2017

In the flood affected area different government and non-government organizations rescue the affected people. The Table-8 shows the rescue operation in the study area in 2017 flood. 2 platoons Bangladesh Army were appointed at Gangachara upazila as a government organization in 13 August, 2017 to rescue flood affected people. But at Kaunia upazila there is no available data about such activities of rescue operation team.

Table: 8. Rescue operation by Bangladesh Army in the study area-2017

| Upazila | Date of report | Name of organization for rescue the people |
|---|---|---|
| *Gangachara | 14.8.17 | Bangladesh Army (2 platoon) |
| Kaunia | Data is not available | |

* Source: Daily Bangla Tribune, 2017

### 4.2.5. Sources of Getting Relief-2017

People get relief from different sources. Some respondents said that they got relief from Union Parishad, Bangladesh Army, BNCC, etc. organizations. These are Govt. organizations. Some people mentioned the name of different NGOs (ASA, BRAC, Grameen Bank, SKS, etc.) as sources of getting relief. Teachers and students of different colleges and Begum Rokeya University gave different items of relief to flood affected people. The table-9 shows that on an average 36.84 % respondents got relief from different Govt. organizations during flood and 19.39% respondents got relief from these organizations in post flood. Many type of NGOs gave different items of relief to 19.67 % of total respondents during flood and 15.79 % in post flood.

Table 9. Sources of getting relief-2017

| Sources | Time | Number of respondents (%) | | |
|---|---|---|---|---|
| | | Lakshmitari | Kaunia Balapara | Average |
| Govt. | During flood | 38.46 | 35.61 | 36.84 |
| | Post flood | 25 | 15.12 | 19.39 |
| NGOs | During flood | 19.87 | 19.51 | 19.67 |
| | Post flood | 13.46 | 17.56 | 15.79 |
| University/college | During flood | 8.97 | 2.44 | 5.26 |
| | Post flood | 7.69 | 2.93 | 4.99 |
| Others | During flood | 5.13 | 6.83 | 6.09 |
| | Post flood | 3.85 | 2.93 | 3.32 |

Source: Field Survey, 2017

### 4.2.6. Distributed, Allocated and Demand of Relief for Flood and River Bank Erosion Affected People

During and post flood period Bangladesh government give different items of relief to affected people. The Table-10 depicts that the distributed, allocated and demand of relief from Bangladesh government at Gangachara and Kaunia upazila in 2016 and 2017 flood. Various types of relief items were given to affected people in above flooding years. These are GR rice, GR cash and dry food (Packet). In terms of 2017 flood 185 MT GR rice and 7.50 lakh taka GR cash were given to affected people at Gangachara upazila. At the same time at Kaunia the amount of distributed GR rice was 93 MT and GR cash was 2.00 lakh taka for flood affected people.

Table 10. Distributed, allocated and demand of relief for flood and river bank erosion affected people

| District | Date of Report | Upazila | Distributed relief | | | Allocated relief | | Demand of relief | |
|---|---|---|---|---|---|---|---|---|---|
| | | | GR rice (MT) | GR cash (Lakh TK) | Dry food (Packet) | GR rice (MT) | GR cash (Lakh TK) | Rice (MT) | Cash (Lakh TK) |
| Rangpur | 19.7.16 | Gangachara | - | - | - | 5 | 0.50 | - | - |
| | 25.7.16 | Gangachara | - | - | - | 10 | - | - | - |
| | | Kaunia | - | - | - | 3 | - | - | - |
| | 28.7.16 | Gangachara | - | - | - | 25 | - | - | - |
| | | Kaunia | - | - | - | 8 | - | - | - |
| | 01.9.16 | Gangachara | 83 | 3.54 | 100 | - | - | - | - |
| | | Kaunia | 14 | 3.15 | 200 | - | - | - | - |
| | 01.9.17 | Gangachara | 185 | 7.50 | - | - | - | 71 | 10.00 |
| | | Kaunia | 93 | 2.00 | - | - | - | 10 | 9.00 |

Source: Office of District Administrator, Rangpur, 2019

### 4.2.7. Relief Activities of different Organizations at Gangachara and Kaunia Upazila-2017

Many local or national, non-government or private organizations were operated the relief activities to flood affected people in the study area besides the government activities. Relief activities of non-government, private and others organizations at Gangachara and Kaunia upazila are shown in Table-11. Various type of relief items like dry food, emergency kits, pure drinking water, treatment and medicine, house repairing materials, etc. were given to flood affected people.

Table 11. Relief activities of different organizations at Gangachara and Kaunia upazila-2017

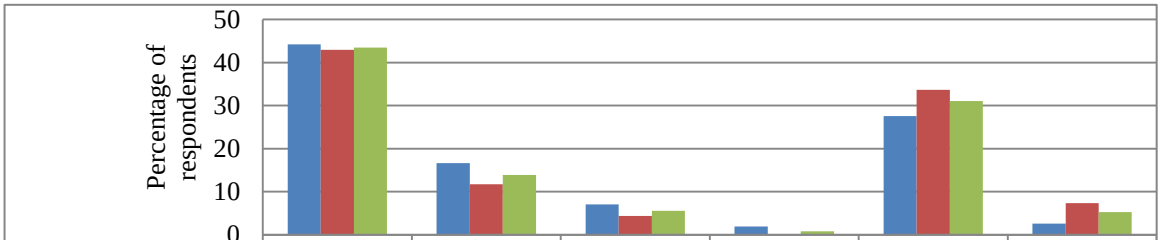
| Upazila | Name of organizations | Relief item | No. of benefited family | Source of data |
|---|---|---|---|---|
| Gangachara | Wealth group, Dhaka and Gangachara reporters club | Dry food | 3500 | Dainik Juger Alo, 15.8.17 and Dainik Bayannor Alo, 15.8.17 |
| | Bangladesh socialist party (BASOD), Rangpur branch | Dry food | 100 | Dainik Juger Alo, 19.8.17 and Dainik Bayannor Alo, 19.8.17 |
| | Bangabandu parishad (Janata bank committee) | Dry food & emergency kits | 420 | Dainik Juger Alo, 23.8.17 |
| | Rangpur chamber | Dry food & emergency kits | 250 | Ibid |
| | Gangachara officers kollan club | Dry food | 600 | Dainik Dabanol, 23.8.17 |
| | Dr. Mafizuddin foundation, Rangpur and Rangpur community medical college | Dry food & emergency kits | 750 | Dainik Bayannor Alo, 24.8.17 |
| | Ispahani tea limited | Pure water, dry food & emergency kits | 1000 | Dainik Juger Alo, 24.8.17 and Dainik Bayannor Alo, 25.8.17 |
| | Mou hostel, Dhap, Rangpur | Dry food & emergency kits | - | Dainik Bayannor Alo, 25.8.17 |
| | Lions club | Dry food & emergency kits | 1000 | DainikDabanol, 25.8.17 and DainikJugerAlo, 26.8.17 |
| | Writers of Rangpur | 45 bundle iron sheet | 45 | DainikJugerAlo, 27.8.17 and DainikBayannorAlo, 27.8.17 |
| | Rotary club Rangpur and eastern bank ltd. | Dry food & emergency kits | 400 | DainikJugerAlo, 27.8.17 |
| | Gangachara haji kollan samiti | Dry food | 200 | DainikBayannorAlo, 27.8.17 |
| | Cristal insurance co. li., Rangpur | Dry food | - | DainikJugerAlo, 27.8.17 |
| | Islami andolon, Bangladesh | Dry food & emergency kits | 130 | Dainik Bayannor Alo, 28.8.17 |
| | Jagoronichakro foundation | Dry food & emergency kits | 1000 | Dainik Juger Alo, 31.8.17 |
| Kaunia | Bangladesh Nationalist Party (BNP) | Rice | 2500 | Dainik Juger Alo, 16.8.17 and Dainik Bayannor Alo, 16.8.17 |
| | Bangladesh Nationalist Party (BNP) | Rice | 1400 | Dainik Bayannor Alo, 19.8.17 |
| | Bangladesh red crescent society, Rangpur unit | Pure water, dry food, emergency kits | 250 | Dainik Bayannor Alo, 24.8.17 |
| | Kaunia girls school mor choymatha zubo sangothon | Dry food, medicine, treatment of livestock | 162 | Dainik Juger Alo, 25.8.17 and Dainik Bayannor Alo, 25.8.17 |
| | Rotary club of roseville and rotary club of uttara | Free treatment, medicine, aman seed & emergency kits | 500 | Dainik Bayannor Alo, 26.8.17 |
| | ASA (NGO) | Free treatment & medicine | 285 | Dainik Juger Alo, 27.8.17 and Dainik Bayannor Alo, 27.8.17 |
| | Islami andolon Bangladesh | Dry food | 120 | Dainik Juger Alo, 28.8.17 and Dainik Bayannor Alo, 28.8.17 |

N.B: Dry food = rice, pulse, flattened rice, parched rice, bakery food, oil, salt, etc.
Emergency kits = medicine, orsaline, water purifying tablet, candle, match-box, soap, toothpaste, etc.

### 4.2.8. Sources of Emergency Medical Treatment-2017

In both study unions about 43.49 % respondents did not receive any treatment from any medical team (Figure-3). Some of them were not affected in any disease and some respondents suffered by diseases but they did not take any treatment. A mentionable rate of respondents (31.03 %) received treatment from their own source. These

sources were medicine store, Quack, Homeopathy, Kobiraji, etc. On the other hand on an average 13.85 % respondents got emergency medical treatment from Govt. medical team. Treatments from Bangladesh Army, village community clinic, medical team from upazila health complex, etc. are included as Govt. medical team. In both study areas 5.54 % of total respondents said that they got treatment from different NGOs in free of cost during and post flood period in 2017.




| | No treatment | Govt. | NGOs | Social community | Own source | Others |
|---|---|---|---|---|---|---|
| Lakshmitari | 44.23 | 16.67 | 7.05 | 1.92 | 27.57 | 2.56 |
| Kaunia Balapara | 42.92 | 11.71 | 4.39 | 0 | 33.66 | 7.32 |
| Average | 43.49 | 13.85 | 5.54 | 0.83 | 31.03 | 5.26 |

Source: Field Survey, 2017

Figure: 3. Sources of emergency medical treatment-2017

### 4.2.9. Activities of Emergency Medical Team in the Study Area-2017

The Table-12 provides information about activities of emergency medical team in the flooding period of 2017. Different type of non-government organizations gave emergency medical service besides the government to flood affected people and livestock in the study area.

Table 12. Activities of emergency medical team in the study area-2017

| Upazila | Name of organizations | Treatment for human/ livestock | No. of benefited family | Source of data |
|---|---|---|---|---|
| Gangachara | Upazila Health Complex (Medical team for all unions) | Human | - | Upazila Health Complex, Gangachara, Rangpur, 2019 |
| Kaunia | Kaunia girls school mor choymatha zubo sangothon | Livestock | 162 | Dainik Juger Alo, 25.8.17 & Dainik Bayannor Alo, 25.8.17 |
| | Rotary club of roseville and rotary club of uttara | Human | 500 | Dainik Bayannor Alo, 26.8.17 |
| | ASA (NGO) | Human | 285 | Dainik Juger Alo, 27.8.17 & Dainik Bayannor Alo, 27.8.17 |

### 4.3. Adaptation Strategies in Post Flood Period

### 4.3.1. Giving Loan to Flood Victims-2017

People receive loan from different sources to fulfill their different purposes. On an average 47.65 % respondents did not receive loan after flood of 2017. Different NGOs such as Grammen Bank, BRAC, ASA, etc. gave loan to 29.64 % of total respondents. People invest their loan money in agriculture sector, business, buying domestic animal or van, rickshaw, etc. These are productive sectors. But some people use this taka in non-productive

sectors like buy food, marriage of daughter, treatment, etc. So it is said that although some respondents used loan in earning sector but some respondents could not increase their income using this loan.

Table 13. Giving loan to flood victims-2017

| Category | | Number of respondents (%) | | |
|---|---|---|---|---|
| | | Lakshmitari | Kaunia Balapara | Average |
| Yes | Relatives | 8.33 | 16.10 | 12.74 |
| | NGOs | 35.90 | 24.88 | 29.64 |
| | Bank | 5.13 | 5.37 | 5.26 |
| | Money lender | 2.56 | 3.41 | 3.05 |
| | Others | 3.85 | - | 1.66 |
| No | | 44.23 | 50.24 | 47.65 |
| Total | | 100 | 100 | 100 |

Source: Field Survey, 2017

### 4.3.2. Emergency Activities to Protect River Bank Erosion by BWDB

Bangladesh Water Development Board (BWDB) actually came into existence as the name of East Pakistan Water and Power Development Authority (EPWAPDA) in 1959 after report of Krug-Mission (1957). EPWAPDA specially started with flood control and river training projects. Later on BWDB was renamed to resume the duties of EPWAPDA after independence of Bangladesh in 1971. Many flood control projects have been undertaken and completed by these organizations. BWDB has been involved in constructing relatively large scale infrastructure such as embankments, sluice gates and regulators in most of the districts (Paul, 2005).In the flooding period many places of the Teestariver are affected by river bank erosion. To protect land area from this erosion, BWDB take many steps in urgent basis. Emergency activities by BWDB in the study area in 2017-2018 fiscal year are shown in Table-14.

Table: 14. Emergency activities to protect river bank erosion in 2017-2018 fiscal year by BWDB

| Name of activities | Name of place | Location of the Teesta river | Estimated Cost (Lakh Tk.) | Tender/ Contract rate (Lakh Tk.) |
|---|---|---|---|---|
| Urgent safety activities | Boyrati-Bagdohora, Nohali union at Gangachara upazila, Rangpur | Right bank of the Teesta river (35.950 km to 36.054 km/104.00 m) | 9.96 | 9.96 |
| Urgent safety activities | Boyrati, Alambiditar union at Gangachara upazila, Rangpur | Right bank of the Teesta river (34.920 km to 35.000 km/80.00 m) | 7.67 | 7.67 |
| Urgent safety activities | Supmari, Nohali union at Gangachara upazila, Rangpur | Right bank of the Teesta river (37.110 km to 37.190 km/80.00 m) | 7.77 | 7.77 |
| Urgent safety activities | Boyrati, Alambiditar union at Gangachara upazila, Rangpur | Right bank of the Teesta river (34.800 km to 34.920 km/104.00 m) | 9.96 | 9.96 |
| Emergency safety activities | Char sankardaha, Lakshmitari union at Gangachara, Rangpur | The Teesta river (0.000 km to 0.080 km/80 m) | 9.40 | 9.40 |
| Emergency safety activities | Sanger bazar, Nohali union at Gangachara upazila, Rangpur | Middle part of embankment of right bank of the Teesta river (35.700 km to 36.200 km/100 m) | 7.24 | 7.24 |
| Emergency safety activities | Kalir char, Bijoybadh at Gangacharaupazila, Rangpur | Middle part of embankment of right bank of the Teesta river (1.900 km to 2.200 km/120 m) | 4.00 | 4.00 |
| Emergency safety activities | Saudpara,Kolkanda union at Gangachara upazila, Rangpur | Middle part of embankment of right bank of the Teesta river (32.400 km to 32.500 km/90 m) | 9.93 | 9.93 |
| Emergency safety activities | Motukpur, Kolkanda union at Gangachara upazila, Rangpur | Middle part of embankment of right bank of the Teesta river (30.700 km to 30.900 km/60 m) | 5.88 | 5.88 |
| Urgent safety activities | Futamari, Nohali union at Gangachara upazila, Rangpur | Right bank of the Teesta river (bell mouth part of tee head groin of Futamari, 40.320 km/80 m) | 12.98 | 12.98 |

Source: BWDB, 2019

## 5. Conclusion and Recommendations

Flood or any natural disaster cannot be stopped fully but proper management system can reduce the magnitude and destructiveness of this natural disaster. In the study area people become economically vulnerable due to flood and riverbank erosion. To recover this situation, GOs and NGOs have taken many steps and people apply their indigenous knowledge. But still now people whirl round and round in poverty trap. For a sustainable flood management in the Teesta floodplain area the study would consider the following recommendations.

- Official warning dissemination bodies have to be formed to reach the warning to rural people in proper time.
- Many flood shelter centers are need to be established, at the same time pure drinking water, proper sanitation system, emergency treatment, etc. need to be ensured in those shelters.
- Embankment should be built-up in total eroded area which can protect the villagers from flood and river bank erosion. Besides monitoring, repairing and maintenances are necessary in regular basis to sustain the embankment.
- Rescue operation, relief activates, emergency medical treatment, etc. should be applied in urgent basis and proper way.
- During and post flooding period many people are being workless. In that case more work opportunities should be created for those people. Various types of agricultural (poultry, livestock, fishery, etc.) or non-agricultural (labor, driver, shopkeeper, etc.) activities should be introduced in that area. GOs and NGOs can take necessary steps to train up people and provide logistics support like capital through soft loan.
- A master plan has to be formulated for proper land use, water and power development.
- Moreover Govt. should take proper policy, more effective plan, more in-depth studies, increase economic strength and resources to adapt with flood or any other disasters.

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# Low Back Pain among Farmers during Harvesting: A Systematic Review

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## Abstract

Low Back Pain is characterized by pain in one or more lumbar or sacral dermatomes that causes decreased function. Pain originating from spinal nerve roots demonstrates multiple pathogeneses. Root-related pain can emerge from the tension events in the dura mater and nerve tissue. The objectives of the present study are to systematic way review the environmental risk factors of Low Back Pain among farmers and explore the efficacy of different types of Physiotherapy intervention. This review mainly focus on working environment, climatic variables, seasonal variation, mal posture and working load of the respondents. Literatures search of online database has been performed from 1999 to 2016 and studies were included found the association among risk factors related to Low Back Pain and its remedies. Review articles show that 26.47%, 17.65%, 14.71%, 14.70%, 11.76%, 8.82% and 5.89% of the articles were on working environment, Pain Characteristics, Treatment Characteristics, Crops, Associated Problem, BMI and Harvesting respectively. A comprehensive rehabilitation program included postural training, muscle reactivation, correction of flexibility and strength deficits, and subsequent progression to functional exercises. Further study is needed for statistical modeling for preventive and curative measures of Low Back Pain.

**Keywords:** Low Back Pain; Harvesting; Farmers; Review

## 1. Introduction

Incidence of musculoskeletal symptoms, information on work exposure, physical workload and leisure time physical activity were related to low back pain. Farmers reported more low back and hip problems (Holmberg *et al.,* 2003). Farmers report low back pain and explained risk factors such as physical work exposures, psychosocial factors and lifestyle. Low Back Pain was associated with musculoskeletal symptoms other than LBP, chest discomfort, dyspepsia, symptoms from eyes, nose and throat mucous membranes, skin problems, work-related fever attacks, and primary care appointments due to digestive disorders (Holmberg *et al.,* 2005).

Low back pain and other musculoskeletal conditions are a significant problem for farmers. The farmer experienced low back pain at a much higher rate than the general working population and higher than other groups of farmer (Wiley, 2006). Farming continues to rank as one of the most dangerous occupations. The most frequent Farmers syndrome are lumbago, shoulder pain, greenhouse-melon farmers had higher prevalence of musculoskeletal symptoms, such as lumbago and shoulder pain (Park and Oh.,2008).

Low back pain remains the predominant occupational health problem in most industrialized countries and low-income countries. Both work characteristics and individual factors have been identified as risk factors. Reducing sickness absence from Low back pain among workers requires focusing on the working conditions of workers and risk factors for Low back pain. Increasing social support in the work environment may have effects in reducing sickness absence (Murtezani *et al.,* 2010)

In addition, the anticipated relationship between low back pain and whole body vibration in farmers was evaluated. The repeated or constant exposure to mechanical shocks may increase the risk of low back pain (Solecki, 2011). Rice grinding activity was a high risk activity with risks. In brief, rice farming was an agriculture activity that harms for farmers' health and safety (Yonelia, and Kurniawidjaja, 2013). Low back pain is a common health problem with concomitant disability which has assumed a public health importance in our setting. Public health efforts should be directed at educating people on occupational activities and lifestyle habits (Ogunbode *et al*., 2013).

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Weight lifting was identified as the main attribute for LBP. LBP leads to work disability that necessitated farmers changing work habits, getting help and needing time off work (Osborne *et al*., 2013). Low Back Pain is the most commonly reported musculoskeletal disorder among farmers. Farmer had his own way of preventing or managing his LBP, including a mix of active self-management and passive coping strategies such as swimming, using ice, spinal manipulation, and taking medication.(Osborne *et al*., 2014). Back care education caused a reduction in pain intensity and functional disability among farmers with chronic mechanical Low back pain. It is recommended that back care education should be used to reduce back pain and disability among farmers (Ayanniyi and Olusoji, 2015).

Review articles related to Low Back Pain among global farmers that related to environmental risk factors were reviewed. Previous researcher discuss about the severity of pain and area of disability among farmers. In the context of Bangladesh there is no previous research found about Low Back Pain of the farmers and its relationship with environmental factors.

## 2. Materials and Methods

Articles were searched from online. The search key words used 'low back pain' during 'harvesting' and its sustainable management using 'Physiotherapy'. Articles were searched to the PubMed, google scholar, Hinary and other searching gate. To identify the articles, searches low back pain, harvesting, sustainable management, Physiotherapy intervention of low back pain, seasonal variation of low back pain and cultivated crops, fruits and vegetables. Total 45 articles were found on LBP of farmers and their treatment of them 51 articles were more related to the research work. Review articles were published after 2009, few were review before 2009 because these work more related to this research work.

## 3. Result and Discussions

This review find out the environmental risk factors, working posture, seasonal variation and proper interventional strategy of the patients with low back pain those who were farmers.

Table 1. Distribution of the literature by affecting factors and treatment strategy

| **Factors** | **Number of articles** | **Percentage** |
|---|---|---|
| Crops related risk factors of LBP | 05 articles | 14.70%, |
| Harvesting related risk factors of LBP | 02 articles | 5.89% |
| BMI related LBP | 03 articles | 8.82% |
| Working Environment related LBP | 09 articles | 26.47%, |
| Pain Characteristics of LBP | 06 articles | 17.65%, |
| LBP with Associated Problems | 04 articles | 11.76% |
| Treatment related LBP | 05 articles | 14.71%, |

Table shows that 26.47%, 17.65%, 14.71%, 14.70%, 11.76%, 8.82% and 5.89% of the articles were Working environment, Pain Characteristics, Treatment Characteristics, Crops, Associated Problem, BMI and Harvesting respectively.

### 3.1. Crops Related Risk Factors of Low Back Pain

Rice cultivation contains several tasks and workers were compelled to adopt some harmful and awkward posture during performing those tasks. Lower back problem was prevalent 48.8% among the workers when all rice cultivation tasks were considered together (Karet and Dhara, 2007). Prevalence of MSDs was 70.0% and 33.9% among greenhouse vegetable farmers and non-greenhouse vegetable farmers, respectively. Working years, body weight and usage of rolling machine were statistically associated with MSDs of greenhouse farmers (Dong *et al*., 2012). Production agriculture such as harvesting in oil palm plantation has been frequently associated with MSD and significant loss of productivities (Birabi *et al.,* 2012).

Rice farmers often have poor sustained postures during a rice planting process and start their farming at an early age. However, individual associated factors of Clinical lumbar instability were known and have rarely been diagnosed in low back pain (Puntumetakul *et al*., 2015). Low back pain is common among rubber farmers, postural factors were identified as being associated with the high prevalence of LBP (Udom *et al*., 2016).

### 3.2. Harvesting Related Risk Factors

Back pain is the most prevalent occupational health problem experienced by much of the world's workforce. However, agricultural work-related back pains occurring among US farmers and it was 26.2%. These findings were significant positive associations between depression, farming activities, and back pain (Xiang *et al*., 1999).The prevalence of Clinical lumbar instability in Thai rice farmers was 13% their mean age were 44±10 years. Number of years of farming experience was found to be significantly correlated with the prevalence of Clinical lumbar instability (Puntumetakul *et al*., 2015).

### 3.3. Body Mass Index Related Low Back Pain

Low back pain was more prevalent in who had farming for a long duration. Severe LBP was significantly linked with age group, low BMI and those above average height was 1.60 m (Birabi *et al*., 2012). Low back pain is one of the most prevalent musculoskeletal disorders in the general population, especially among manual laborers BMI, exposure to pesticides, and tapping below knee level were statistically associated (Udom, 2016).

### 3.4. Working Environment Related Low Back Pain

Farmers showed higher prevalence changes for intervertebral disc disorders than other occupational workers (Cha *et al.*, 2009). The frequency of back pain is related with whole body vibration, as well as with prolonged sitting position, wrong body posture and physical work load. The repeated or constant exposure to mechanical shocks may increase the risk of low back pain (Solecki, 2011).

Back pain was 66.0% and it was dependent work quantity and quality the associations between potential risk factors of farming pattern (Wang *et al*., 2012). Most common musculoskeletal disorders affecting the farmers of Kanpur-Rural, lower back pain were 60%, knee pain were 39%, shoulder pain 22%, neck pain 10%. Poor postures and lack of ergonomic awareness in the farmer was affected (Gupta and Tarique, 2013).There is a high prevalence of LBP among the respondents was 74.4%. Low back pain was described as moderate in 53.4%. Prolonged bending 51.3% was the most related risk factor. A considerable proportion was 65.9% of the respondents were unable to continue some of the previously enjoyed activities. Males had significantly higher prevalence, recurrence and duration of LBP than the females (Tella *et al*., 2016). Clinical lumbar instability is one of the subgroups of chronic non-specific low back pain. Thai rice farmers often have poor sustained postures during a rice planting process and start their farming at an early age (Puntumetakul *et al*., 2014).

Prevalence of low back pain was 83.1%. Farmers with high stress levels were more likely to have low back pain and it was associated with the weekly work duration and stress (Keawduangdee *et al*., 2015). The lower back was 57.7%, followed by shoulders was 44.0%, and neck was 39.6%. MSD prevalence was significantly related to time spent performing biomechanically demanding tasks such as heavy lifting and working with arms overhead (McMillan *et al*., 2015). Work-related exposures and inflammatory responses might be involved and identify plasma proteins that differentiated farmers with MSD of these protein biomarkers might eventually be used to identify and prevent work-related MSD (Ghafouri *et al*., 2016). Occupational determinants of health such as vibration, heavy lifting, and awkward postures are important in the development and progression of low back disorders (Trask *et al*., 2016).

### 3.5. Pain Characteristics of Low Back Pain

The most commonly experienced MSDs were back pain 37% and neck/shoulder pain 25%. Other MSDs experienced in the previous year included knee pain 9%, hand, wrist and elbow pain 9%, ankle/foot pain 9% and hip pain 8%. Back pain was more prevalent in full time farmer, while prevalence of hip pain was greater in farmers who were older, full time, farming for longer and working for longer hours (Osborn *et al*., 2010). Prevalence rates of LBP were 77%, 56% and 49%, respectively. No relationship between age and LBP was found. Ninety-five percent of LBP were chronic, experiencing pain longer than 12 weeks with a mean duration was 5.6 years (Taechasubamorn *et al*., 2011). Prevalence of MSD among farmers was 90.6% while 1-year MSD

prevalence was 76.9%. LBP prevalence was 75% while 1-year LBP prevalence was 47.8%. The next most common regional MSDs reported range from 10.4-41% to 3.6-71.4% (Osborne *et al.,* 2012).

Farmers experience musculoskeletal symptoms such as pain and disability at a higher rate than other professions. Musculoskeletal symptom prevalence varied by age and joint, with the lowest prevalence of 28% for the elbow and the highest prevalence of over 73% for the lower back (Tonelli *et al*., 2015). Chronic low back pain prevalence was 8·4%. Increasing age, rearing two or more species of livestock, exposure to tasks that require heavy physical exertion, working in awkward postures, green tobacco sickness, pesticide poisoning, and minor psychiatric disorders were associated with CLBP (Meucci *et al*., 2015). The prevalence of low back pain was found to be 42%. The majority of women were 60.9% with low back pain experienced moderate disability (Ahdhi *et al*., 2016).

### 3.6. Low Back Pain with Associated Problems

The frequency of low back was 63.8%, leg/foot was 43.3%, shoulder was 42.9%, wrist/hand/finger was 26.6%, arm/elbow was 25.3%, and neck was 21.8%. Low back pain was more frequent in those with over 30 years of farming experience (Min *et al*., 2016). Musculoskeletal pain in multiple areas was 91.3%, and low back pain was 63.8% was the most frequent site of pain. 53% of participants had worked in farming for more than 30 years, and workers involved in dry-field farming comprised the largest subgroup was 41.5% (Jo *et al*., 2016).

Hormones play an important role in the etiology and pathophysiology of a variety of musculoskeletal degenerative diseases and it accelerated disc degeneration due to relative estrogen deficiency (Wang *et al.,* 2016). Chronic low back pain is a common orthopedic condition that co-exists with depression. The prevalence of depression in patients with CLBP was observed to be 39.5% which is comparable to the reports of previous studies in the developed countries (Namgawa *et al*., 2016).

### 3.7. Treatment Related Low Back Pain

Prevention might be more beneficial in the management of LBP. With respect to prevention, the knowledge of risk factors is essential. Exposures involving spinal mechanical load reducing is frequently discussed as a potential benefit for LBP (Bakker *et al*., 2009). The socio-demographic differences between farmers and non farmers with chronic back disorders may impact the design of effective interventions and have implications for health services planning and health care delivery (Saskatchewan and Josh, 2010). Compared to general exercise, core stability exercise is more effective in decreasing pain and may improve physical function in patients with chronic back pain. There was no significant long-term differences in pain severity were observed between patients who engaged in core stability exercise versus those who engaged in general exercise (Wang *et al.,* 2012). The application of an instruction protocol Intervention for low back pain was effective in improving patient knowledge and practice, with associated amelioration of the severity of pain and disability among them (Taha *et al*., 2015). Low back pain was found to be a cause of work absenteeism of working population. Fifty percent of the respondents suffered from low back pain. Back care education can be provided to the farmers (Kamruzzaman, 2016).

### 3.8. Bangladesh Perspectives

Bangladesh is a lower-middle income, most densely populated countries in the world and continues to face numerous political, economic, social and environmental challenges, including political instability, poverty and overpopulation. Food security is also constrained by low level of productivity, profitability, and high yield gap; relatively slow rate of take up of new technologies; inadequate level of private sector interest and investments in agricultural value chain; fluctuations in agricultural production; and limited resources for building resilience to climate change. They suffered different types of disorders including back pain, neck pain, knee pain, wrist and elbow pain due to their working posture, intensive farming and heavy weight lifting and carrying and exposed to different types of health risk type of farming activity. In Bangladesh there is no previous research finding about this risk factors of musculoskeletal disorders of the farmers of rural community.

## 4. Conclusion

This review found that working environment, crops pattern, seasonal variation, working hours, working duration, bending posture were the risk factors of Low Back Pain among farmers. Several Physiotherapy intervention strategies were the sustainable management of these issues.

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# Effect of Weather Conditions on Stroke: A Review

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## Abstract

Stroke is a focal episode of neurological deficit and brain tissue damage, either infraction or hemorrhage which persists for more than 24 hours and resultant weaknesses the half of the body. The objectives of the study to review the weather condition related to risk factors of stroke. This reviewed mainly focuses on weather conditions-related articles, which are mainly related to stroke. A literatures search of online database has been performed from July 2019 and the study found the association among risk factors related variables and stroke and its remedies. Reviewed articles show that 41.8, 21.8, 12.7, 9,1, 9.1, and 5.5% had a temperature, atmospheric pressure, humidity, snowfall and rainfall, seasonal variation, and air pollution-related respectively. It was found from the review that low temperature, low atmospheric pressure, and less humidity were responsible for intracerebral hemorrhage contrast to the ischemic stroke it may have occurred at high temperature, high atmospheric pressure, and more humid conditions. However, the mean lowest temperatures of stroke occurrence had 1.33°C, and the mean highest temperature of stroke occurrence had 14.50°C and a range between -20°C and 30°C.

**Keywords:** Stroke; Weather Conditions; Seasonal Variation.

## 1. Introduction

Health is an important issue and needs special attention to their medical checkup but in our country, there are no formal health checkup facilities for this risk factor did not find out and non-communicable diseases suddenly attack human health, stroke is one of them. Stroke is a focal episode of neurological deficit and damage of brain tissue, either due to infarction or hemorrhage which persists more than 24 hours. Ischemic, hemorrhagic, and transient ischemic attacks were common types (Hauser, 2010). History of hypertension, diabetes mellitus, central obesity, psychosocial stress, and smoking were the risk factors of ischemic stroke, whereas alcohol intake was the risk factor for haemorrhagic stroke (Donnel *et al.,* 2010). External stimuli, such as temperature, atmospheric pressure, and humidity were responsible for stroke (Cao *et al.,* 2016). High annual rainfall, average temperature, cold days may affect the risk of stroke (Matsumoto *et al.,* 2010). Higher body temperature resulting in excess fluid loss causes hemoconcentration, which increased the incidence of ischemic stroke (Kvistood *et al.,* 2012). The high and low temperature was directly influenced by the risk of stroke (Chen *et al.,* 2013). Maximum temperature and atmospheric pressure combined with a significant predictor of stroke. Daily fluctuations in atmospheric pressure also had significant effects on stroke incidence (Nocera *et al.,* 2014). Hurricanes or tropical storms increased the risk of ischemic stroke but daily lowest and highest air pressure and temperature fall in both ischemic and subarachnoid hemorrhages (Tarnoki *et al.,* 2017). Stroke is the leading cause of death and disability in Bangladesh. Rehabilitation services have few yet integrated into the Bangladesh health system. Only a few government and non-governmental organizations provide rehabilitation for stroke patients (Mamin *et al.,* 2017).

Stroke causes impairments, long-term disability resulting from lead to persistent difficulties with walking. After a stroke, secondary complications may arise such as joints contracture and deformity, heart disease, bedsore, urinary tract infection, respiratory infection were more common (Eng and Tang, 2007). Stroke is one of the top 5 leading causes of death and one of the top 10 causes of hospitalization in Malaysia with the greatest burden of disease based on disability (Loo and Gan, 2012). In the Philippines, the prevalence ranged from 1·9 to 6·59%, and the government should emphasize primary and secondary prevention strategies (Loo and Gan, 2013). In India, China, Philippines, Thailand, Sri Lanka, Iran, Pakistan, Nepal, there has been a rapid increase in stroke

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mortality (Singh, 2000). In Bangladesh, which is ranked 84 in WHO's mortality rate index, stroke is the third leading cause of death. Hypertension followed by heart disease and diabetes were found to be the main risk factor for stroke (Zaman *et al.*, 2014). In the year 2008, a population-based study was conducted ICDDR'B in Matlab branched and found that the prevalence of stroke in Bangladesh was 0.3% and mortality of stroke was 25.2% (Mateen, 2012). In this study, the aim was to identify the effect of weather conditions on stroke, however, the temperature, humidity, atmospheric pressure, snowfall or rainfall, thunderstorms were influences the fall on stroke.

## 2. Materials Methods

Articles were searched online July 2019. The search key words like stroke and its environmental impact. Articles were searching to the PubMed, Goole scholar, Henary and other searching gates. Materials collected from the printed journal, article, periodical, annual proceedings, conference, and seminar proceedings. To identify the articles, search stroke, environmental impact, seasonal variation. Total 85 articles were found related to stroke among them 54 articles were more related to the research work. Reviewed articles published after 2010, few articles reviewed before 2010 because these work more related to this research work.

## 3. Results and Discussion

This reviewed work was conducted to find out the environmental risk factors including temperature variation, seasonal variation, biological risk factors, and social risk factors of the patients who were suffering from a stroke.

Table 1. Distribution of the literature by risk factors of stroke

| **Factors** | **Number of articles** |
|---|---|
| Temperature | 23 articles |
| Atmospheric Pressure | 12 articles |
| Humidity | 07 articles |
| Snowfall and Rainfall | 04 articles |
| Seasonal Variation | 05 articles |
| Air Pollution | 03 articles |
| Total | 54 articles |

Table 1 shows 23 reviewed articles were temperature related, 12 articles were atmospheric pressure related, 07 articles were humidity related, 04 articles were snowfall and rainfall related, 05 articles were seasonal variation related and 03 articles had air pollution related were included in this article.

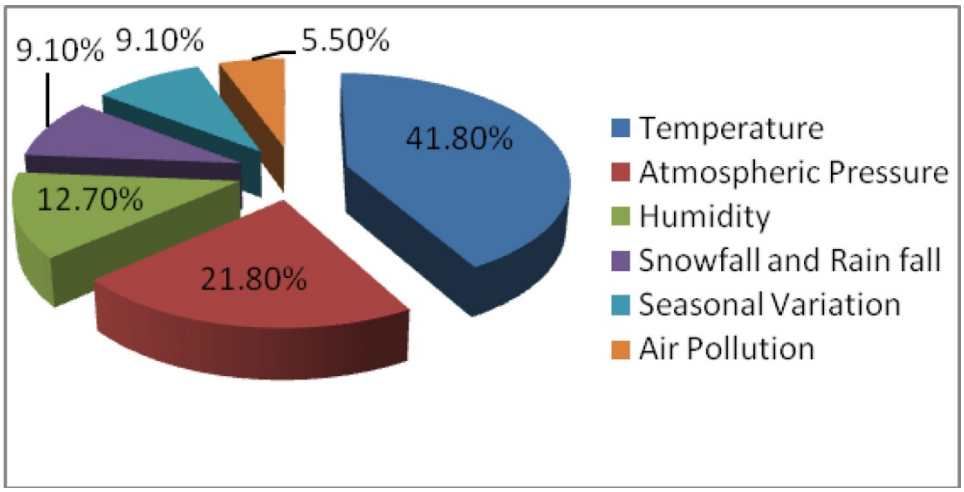


Figure 1. Distribution of the Study Subject by Weather Conditions

Figure 1 shows that 41.8, 21.8, 12.7, 9,1, 9.1, and 5.5% of the reviewed literature had a temperature, atmospheric pressure, humidity, snowfall and rainfall, seasonal variation and air pollution respectively were included in this paper.

### 3.1 Temperature related Risk Factors of Stroke

From the year 2014 to 2017, a national time-series analysis was conducted in 184 cities in China and found that short-term temperature (increased) variability exposure increased the hospital admission for cardiovascular diseases, ischemic heart diseases, heart failure, and ischemic stroke (Tian *et al.,* 2019). Patient with a low-temperature group (<13°C) showed an increased proportion of patients with hypertension and large artery atherosclerotic stroke, more prolonged prothrombin time and thromboplastin time was reduce in the low-temperature group (>13°C), it was the factors of a degree of neurological impairment of patients with ischemic stroke (Chen *et al.,* 2019). Mortality of hemorrhagic stroke following exposure to cold temperature and it was independently of snowfall. Relative to 0°C, a temperature of -20°C was associated with 1.7 times the odds of hemorrhagic stroke (Polcaro-Pichet *et al.,* 2019).

From the years 1996 to 2013, a non-linear model was fitted in Ontario, Canada to estimate the cold and heat effects on hospitalization from ischemic heart diseases and ischemic stroke. The study found that a 9% increased in daily hospitalization for CHD, 29% increased for AMI, 11% increased for stroke relative to days with an optimal temperature. These estimates translate into 2.49% of CHD hospitalization attributable to cold and 1.2% from heat. Additionally, 1.71% of stroke hospitalizations were attributable to cold (Bai *et al.,* 2018). Large changes of mean ambient temperature were associated with ischemic stroke, with an increase between 1.5 and 2.1% for every degree Celsius rise in mean temperature. Intracerebral hemorrhage was associated with temperature fluctuations independently, the study found that significant association between the incidence of intracerebral hemorrhage and monthly mean low temperature and it was about under 17°C. Temperature variations were associated with increased subarachnoidal hemorrhage and these changes during the previous 24 hours or day-to-day. In high ambient temperature, the proposed mechanisms involved in higher stroke risks are increased sweating and skin blood flow, producing dehydration, increased blood viscosity, hemoconcentration, and elevated cholesterol levels (Lavados *et al.,* 2018).

From the year 2000 to 2010, stroke register data were used in Kaunas, Lithuania with a sample size 4038 and found that ischemic stroke had 80.4% and hemorrhage stroke had 19.6%. Whereas, the low temperature was associated with a higher incidence of hemorrhagic stroke in women, and high wind speed was associated with a higher incidence of ischemic stroke (Tamasauskiene *et al.,* 2017). Temperature change during the day was positively correlated with ischemic stroke in men. Temperature differences over the preceding 24 hours had a negative correlation with all strokes, especially among older women. Diurnal variation of atmospheric pressure was also significantly associated with the incidence of ischemic stroke (Lim *et al.,* 2017).

A systematic review and meta-analysis were conducted to investigate the association between stroke and both high and low temperatures, and health assessment. 1°C change and the occurrence of major adverse cerebrovascular events, 1.1 and 1.2% increase for hot and cold effects separately. The same trends can be found in both effects of mortality and the cold effect for morbidity. Hot temperature acted as a protective factor of hemorrhage stroke was 1.9%, however, it acted as a risk factor for ischemic stroke and it was 1.2% (Lian *et al.,* 2015). The incidence rate of ischemic stroke in Boston city was 1.09%. The study also found the association between ischemic stroke and ambient temperature was stronger on days with higher levels of relative humidity (Mostofsky *et al.,* 2014). The incidence rate of stroke was approximately 30% higher in the previous 10 days and it was a decline in the minimum temperature. Sudden decline in the minimum temperatures was associated with a higher incidence of stroke (Gomes *et al.,* 2014). The decreased temperature had related to an increased rate of ischemic stroke after 24 to 48 hours of exposure to cold weather (Hashizume *et al.,* 2012). It was found that both hemorrhagic and ischemic stroke were low when the ambient temperature at 6, 12, and 24 hours before initial symptoms was <20°C and peaked at temperatures between 23°C and 24°C (Goggings *et al.,* 2012). The study revealed that 19.6% had an intracerebral hemorrhage and 75.3% had an ischemic stroke. Decreased in maximum, minimum, and mean temperature had a significant relationship to increased ischemic events (Magalhaes *et al.,* 2011).

From years 2004 to 2006, 176 medical records of patients were analyzed after having a stroke at the hospital Israelita Albert Einstein. Stroke occurrence increased after a variation of 3ºC between 6 and 24 hours before symptoms (Coelho *et al.,* 2010). Increased the rate of occurrence of acute intracerebral hemorrhage by 11.8% for each degree drop in the diurnal temperature range from the day before the event (Matsumato *et al.,* 2010). Changes in temperature impact many cerebrovascular risk factors, including serum lipid, fibrinogen concentration, and blood pressure. The lower temperature increased stroke risk, while changes in atmospheric pressure may link with increased intracranial hemorrhage risk (McArthur *et al.,* 2010). Variability of ambient temperature influences the risk of acute ischemic stroke of Canadian people (Gregory *et al.,* 2009). Neighborhood environment may influence stroke risk in certain gender and age groups (Lisabeth *et al.,* 2007). In the case of acute stroke, an increased risk of hospitalization occurred when temperature changes exceed ±5°C (Kyobutungi *et al.,* 2005). A prospective was conducted of Africans living in Kinshasa Congo with 1032 sample and found that hematocrit was mostly correlated with average air temperature and atmospheric pressure. Highest levels of systolic blood pressure, fibrinogen, body temperature, resting heart rate, duration of coma, and incidence of all stroke types and ischemic stroke (Longo-Mbenza *et al.,* 1999). Effect of environmental factor changes on stroke incidence and mortality rates (Feigin and Wiebers, 1997). The association between weather and stroke was found, however, the occurrence of intracerebral hemorrhage more frequently on cooler days (Chen *et al.,* 1995).

Table 2. Distribution of the literature by risk factors of stroke

| **Highest Temperature** | **Lowest Temperature** | **Types of Stroke** | **References** |
|---|---|---|---|
| 30°C | 13°C | Ischemic | Chen *et al.,* 2019 |
| 0°C | -20°C | Hemorhagic | Polcaro-Pichet *et al.,* 2019 |
| 22°C. | 7°C. | Subarachnoidal Hemorrhag | Lavados *et al.,* 2018 |
| 24°C | 23°C | Ischemic stroke | Goggings *et al.,* 2012 |
| 10°C | 5°C | Hemorhagic Stroke | Kyobutungi *et al.,* 2005 |
| 1°C | -20°C | Hemorhagic Stroke | Lian *et al.,* 2015 |
| $14.50 \pm 12.64$ | $1.33 \pm 17.67$ | Mean ± SD | |
| 0°C and 30°C | -20°C and 23°C | Range | |

Table 2 shows that the mean lowest temperature of the stroke occurrence had $(1.33 \pm 17.67)$°C and the mean highest temperature of the stroke occurrence had $(14.50 \pm 12.64)$°C, whereas the ranges between 0°C and 30°C had the lowest temperature and -20°C and 23°C had the highest temperature respectively.

### 3.2 Atmospheric Pressure related Risk Factors of Stroke

The high temperature in hot months may trigger first-ever strokes, and low atmospheric pressure may exacerbate the effect. Associations between heat and first-ever strokes for intracerebral hemorrhage (Bao *et al.,* 2019). There was a significant correlation between daily barometric pressure variation and daily stroke hospitalization (Guan *et al.,* 2019). The frequency of ischemic stroke significantly increased when thermo-hydrological index either cooler or warmer from the previous day. Intracerebral hemorrhage frequencies significantly decreased on thermo-hydrological index was warmer and increased high atmospheric pressure days. Intracerebral hemorrhage increased when thermo-hydrological index got extremely cooler in 4 days prior **(**Mukai *et al.,* 2017). A direct relationship between atmospheric pressure above 1016 millibars and both systolic blood pressure and diastolic blood pressure in hypertension patients. Significant changes in the blood pressure were found at atmospheric pressure differences between 1007 and 1024 millibars (Charch *et al.,* 2017). Diurnal variation of atmospheric pressure was also significantly associated with the incidence of ischemic stroke (Lim *et al.,* 2017).

From the year 2016, 206 patients were selected to assess the effects of changes in barometric pressure and outdoor temperature on the incidence of intracerebral hemorrhage. Drops in atmospheric pressure were associated

with different types of intracerebral hemorrhage (Honig *et al.,* 2016). Increased 1hPa in atmospheric pressure for the risk of ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. It was also revealed that 1 percent increased humidity for risk of ischemic stroke and intracerebral hemorrhage (Cao *et al.,* 2016). It was observed that a significant difference in blood pressure was recorded during the lower and higher range of atmospheric pressure. A significant inverse relationship between atmospheric pressure and blood pressure was identified (Kaminski *et al.,* 2016).

Non-lacunar stroke was related to a fall in atmospheric pressure, while intracerebral hemorrhage was associated with rising atmospheric pressure. However non-lacunar stroke was related to rising in temperature and intracerebral hemorrhage was associated with a fall in temperature (Jimenez-Conde *et al.,* 2008)**.** It was revealed that 90% of the patients suffered from ischemic stroke, 34% were lacunar, 10% had a hemorrhagic stroke. Increased temperature in the risk of ischemic stroke and decreased atmospheric pressure increased the rate of hemorrhagic stroke (Dawson *et al.,* 2007). There was a significant correlation between decreased atmospheric pressure and AMI and no correlation between decreased atmospheric pressure and stroke (Houck *et al.,* 2005). There was a relationship between high atmospheric pressure and increased incidence of subarachnoid hemorrhage (Buxton *et al.,* 2001).

### 3.3 Humidity related Risk Factors of Stroke

In the year 2004 to 2006, a retrospective study was conducted with a sample size 11930 and found that rapid increases or rapidly decreased in humidity increased the incidence of stroke. Extremely low and high humidity influences the increased number of strokes (Slatina *et al.,* 2013). Decreases in temperature and humidity on the day of or day before stroke have been significantly linked to ischemic stroke and transient ischemic attack (Petrov *et al.,* 2011). Cerebral infraction correlated with more humidity factors, fewer sunshine hours, fewer solar radiation factors, and greater amount of precipitation (Ebi *et al.,* 2004).

### 3.4 Snowfall and Rainfall related Risk Factors of Stroke

Lower temperature and radical humidity change were identified as risk factors for stroke and a decreasing temperature was also associated (Matsumaru *et al.,* 2020). Sudden cold water exposure increases sympathetic tone, which is mediated by thermo-receptors, activated by the rapid fall in skin temperature, it induced an increase in blood pressure and this cause fall in stroke in high-risk individuals (Benedict and Pandian, 2014). The mortality increased on days of extreme cold conditions. Snowfall was greater than 3cm and when the temperature below -7°C and mortality due to ischemic heart diseases and cerebrovascular cause (Gorjanc *et al.,* 1999). There was a statistically significant negative correlation between mean temperature with admission for cerebrovascular diseases, intracerebral hemorrhage, ischemic stroke, and transient ischemic attack, these correlations were independent of any seasonal variation (Azevedo *et al.,* 1995).

### 3.5 Seasonal Variation related Risk Factors of Stroke

From the year 2006 to 2007, a survey was conducted among 2319 stroke patients in Wujin, a city, southeast China to evaluate seasonal variations in stroke incidence. Stroke incidence was highest in September and lowest in January, however, autumn had the highest incidence of both ischemic and cerebral hemorrhage (Jin *et al.,* 2018). Cardioembolic stroke was more common in winter. Ischemic stroke patients had more moderate to severe initial neurological deficits in winter and spring and ischemic stroke was not winter dominant disease (Toyoda *et al.,* 2018). There was a higher frequency of stroke in the United State in winter and it was 116862 in winter, 113689 in spring, 113569 in summer, and 113518 in the fall season. Wormer and wetter weather conditions were independently associated with better outcomes (Chu *et al.,* 2018). There were more strokes in winter (December-March) than summer (June-September) (Mateen, 2012). There was no association between weather changes and stroke occurrence (Field and Hill, 2002).

### 3.6 Air Pollution related Factors of Stroke

Air pollution (sulfur dioxide, nitrogen dioxide, and carbon monoxide) was positively associated with ischemic stroke, whereas only a significant association with nitrogen dioxide and hemorrhagic stroke (Liu *et al.,* 2017). There was a negative correlation between average temperature and intracerebral hemorrhage whole only ozone was independently associated with subarachnoidal hemorrhage (Han *et al.,* 2016). The study showed that

exposure of particulate mattress 12 to 14 hours greater risk of ischemic stroke and it was PM 2.5 (Wellenius *et al.,* 2012).

### 3.7 Research Gap

In a nutshell, it was found some gaps while critically reviewing evidence-based paper. Authors of reviewed articles from different countries emphasize on risk factors of stroke and climatic variables of South Asian countries, African countries, the United Kingdom, and the United State of America. In the context of Bangladesh, there was no previous study found regarding the effect of weather conditions on stroke.

### 3.8 Conclusion

The study concludes that atmospheric pressure, humidity, snowfall, or rainfall, temperature including heat and cold exposure also seasonal variations were the risk factors of stroke.

### 3.9 Recommendations

Based on the review findings, the following recommendations made to prevent and reduce the risk of stroke.

1. Raising awareness among the population about the risk factors of stroke and its severity
2. A continuous health education program by using print media and electronic media
3. Further study is needed to assess climatic and geographical risk factors of stroke patients in Bangladesh.

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# Suitability and Economic Profitability of Land Conversion for Mango Orchard in Charghat Upazila, Rajshahi

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## Abstract

Orchard has emerged as an important area for alternative cropping pattern due to higher returns and productivity. This study was conducted to determine the suitability and economic profitability of land conversion to mango orchard in Charghat Upazila, Rajshahi. A total 85 mango orchard growing farmers were randomly selected for the interviewing. About (44%) lands were converted to mango orchard from cereal crops. The land conversion was higher in Byaluxmpur (27%), Nimpara (20%) followed by Charghat (14%) union, respectively. The main reason of this conversion was higher quick profit compared to other crops. About 90% farmers have converted crop land into mango orchard because quick profit and economic profitability. Mango orchard farmer obtained an average yield 103 kg/ha mango in 1st quarter (year 1-3) and then production increased sharply to 21694 kg/ha in 5th quarter (year 13-15). Although inter cropping cultivation becomes popular to many farmers because of additional income. While increasing canopy coverage of mango causes yield loss of both rice and other crops. In 15 years, old mango intercrop yield reduces drastically (90%). More than 92% farmers obtained increased income, whereas 77% achieved better livelihoods due to orchard cultivation. However, there is a possibility to decrease of crop land with crop production which may have adverse impact on food security. Therefore, planned mango orchard cultivation is needed along with food security in Charghat Upazila, Rajshahi.

**Keywords:** Economic Profitability; Land Conversion; Mango Orchard; Crops

## 1. Introduction

The concept sustainable agriculture or farming involves producing quality products in an environmentally benign, socially acceptable and economically efficient way (Addeo *et al.,* 2001). Farmers' crop diversification decision is considered as one of the important economic decisions which have strong influence on their welfare in terms of income level and returns (Khandoker *et al.,* 2017).With the growth of a country's economy, agricultural land is usually transferred to non-agriculture as the demand fornon-farmproducts and services increased (Qusasem, 2011).

The sustained economic growth, rising per capita income and growing urbanization have caused a shift in the consumption patterns in favor of high value crops like fruits and vegetables from staple food crops such as rice and wheat (Joshi, 2005). While taking decisions farmers make choices in the context of their production possibility frontier, their expectations of relative prices and their sense of risk from both an agronomic and market perspective for various alternatives. The first decision is about the choice of number of crops. While taking decision on number of crops and level of spread in the cropping pattern, farmers also take another critical decision as to which crops to produce and how much land to be allocated to that crop. Hence, the area substitution for crop decision comes from this concept. In recent decades, Charghat Upazila in Rajshahi, demand for mango orchard has grown much faster than that of food grains. In farm planning, farmer decided what to produce, how to produce, and how much to produce (Van and Keller, 2006). The farmer has to decide between alternative uses of resources at his disposal in order to address these three different but inter-related questions. It was observed that in the study area highly unfavorable for crop cultivation and production but favorable production of orchard like mango. Inadequate irrigation management, hard industry, seasonal casual labour shortage, soil nutrient depletionman power less are adding more pressure of farmer on natural resources for sustainable crop production. On the contrary, mango cultivation high productivity and draw quick profit, low water requirement, favorableagro-ecological condition, ready market and also environment friendly farmer's perception for suitable orchard cultivation.

The total agricultural land in the study area has been decreased gradually. Otherwise, orchardland increasing steadily and its production increase sharply. On the other hand, farmer's discard crop cultivation for years because of lack of justifiable economic return and profitability. Another aspect is the lack of younger generation

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in agriculture due to low return. Thus, farmers convert their crop land into mango orchard. Annual conversion of farm land is estimated to be 0.93% in the study area. Previous researcher observed that annual conversion of farm land is estimated to be 0.56% and the country's loss of rice production is also estimated to be between 0.86 and 1.16 percent (Quasem, 2011).

About 75% farmers converted crop land into orchard because of water scarcity, high profitability, easy cultivation process, land suitability and favorable environment for orchard cultivation and there is a possibility to decrease food grain, pulses, oil seed and vegetable production in the long run.

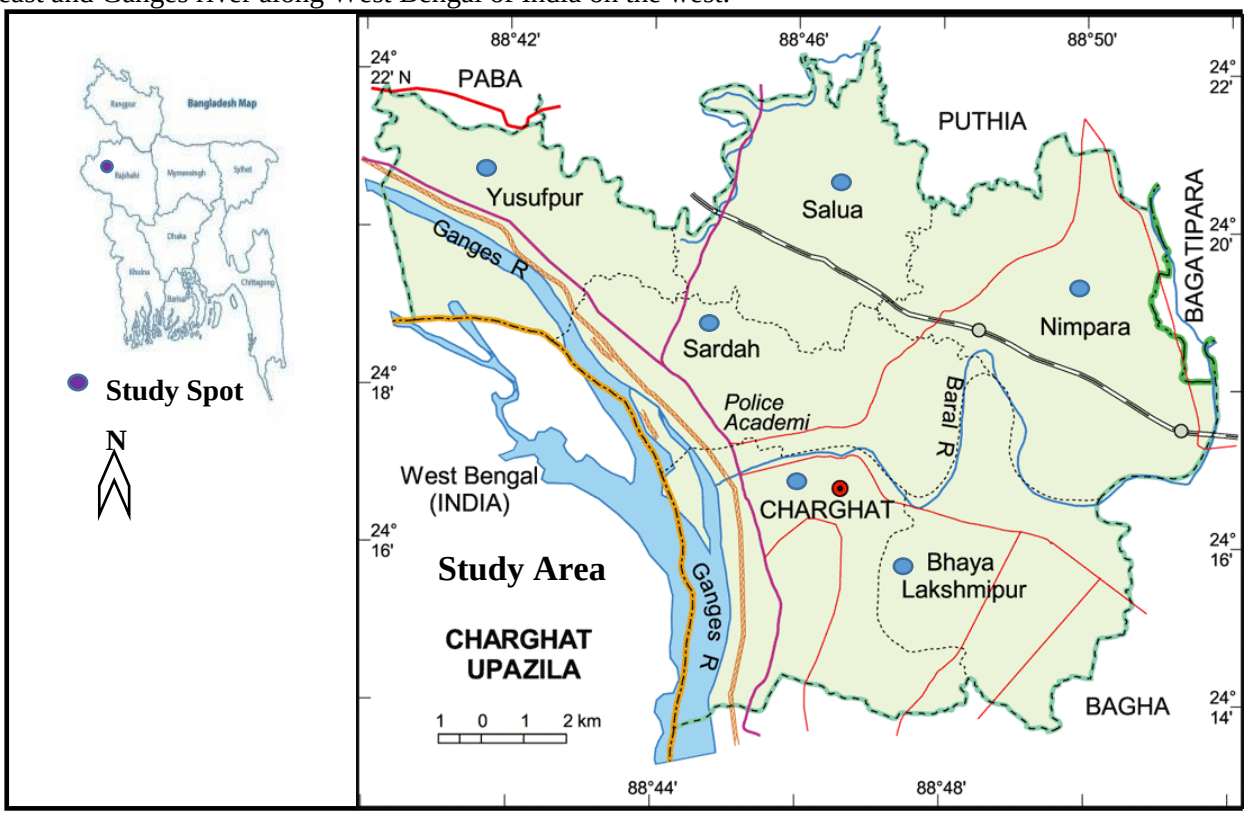
According to FAO, 2019 over the last 18 year the rapid production of mango has been the highest in Bangladesh. The production has increased by 16% per year. In 2016-2017, the production and the land area of fruits were 70137.4 (M.ton) and 4384 ha, respectively (Source: Department of Agriculture Extension (DAE), Charghat Upazila, Rajshahi, 2018). Especially, orchard cultivation has accomplishment motivation within the farmer in the study area. In Charghat Upazila, the mango production was 0.549 lakh ton in 2016-17 with corresponding areas 0.038 lakh. ha (DAE, 2018). The most of the study area were dominating mango orchard cultivation. So its cultivation, production, cost return and effects have been emphasizing in the study. This study was conducted considering the three objectives:

1) To determine and compare the relative profitability of mango production with competitive cereal crops.
2) To estimate the financial profitability of mango orchard production.
3) To determine the positive and negative impact on income, livelihood and food security in study area.

## 2. **Materials and Methods**

### **2.1. Study Area**

The study area includes Charghat Upazila of Rajshahi district which area is 164.52 sq. km and six Unions as Yusufpur, Salua, Nimpara, Sardah, Charghat, Bhayalakshimipur and one Pauroshava (Municipalities) (Banglapedia, 2019). The area is located in between $24^0 14'$ and $24^0 22'$ north latitudes and in between $88^0 46'$ and $88^0 52'$ east longitudes and bounded by Puthia and Paba Upzila on the north, Bagatipara and Bagha Upzila on the east and Ganges river along West Bengal of India on the west.




Study area map and location in Charghat Upazila of Rajshahi district (Source: BBS, 2010)

### 2.2. Data Collection and Process

The study was based on primary and secondary data. For primary data collection, formal and informal discussions were held with 85 mango farmers who converted their crop land into mango orchard. Questionnaires interviews from respondences and field observation data were collected from July to October 2019. Secondary data were collected from literature review through academic journals, field documents, project reports and relevant offices such as Department of Agricultural Extension (DAE), Bangladesh Bureau of Statistics (BBS). After data collection, necessary coding, tabulation, statistical analysis and compilation were done by using MS word, Excel and SPSS software.

### 2.3. Sampling Technique and Sample Size

The study was conducted in Charghat Upazila of Rajshahi district during July to October 2019. All unions *viz.*, Yusufpur, Salua, Nimpara, Sardah, Charghat, Bhayaluxmpur) and Paurosova of Charghat Upazila were selected as the study area. Field data were collected by using pre-tested questionnaires during field investigations. A total of 85 orchard growing farmers were randomly selected for interview.

### 2.4. Analytical Techniques

Collected data were summarized, tabulated and analyzed to fulfill the objectives of the study. Using different statistical tools descriptive statistics like averages, percentages and ratios were used in presenting the results. The profitability of crops and mango orchard production was examined on the basis of gross return, gross margin and benefit cost analysis. Besides, the opportunity cost of family supplied labour was taken into consideration in estimating total cost. Land use cost was calculated on the basis of per year lease value of land.

### 2.5. Benefit Cost Ratio (BCR)

The BCR of an investment is the ratio of counted value of all cash inflows to the counted value of all cash outflows during life span of orchard. It was estimated by the formula of (Khandoker *et al*., 2017).

$$\text{BCR}= \sum \frac{n}{c} = \frac{Bt/(1+r)t}{Ct/(1+r)t}$$

Where,

Bt = Total benefit (Tk/ha) in time, Ct = Total cost (Tk/ha) in time t, r = Rate of interest (discount rate), t = Number of years (t = 1, 2, 3 ….n)

## 3. Results and Discussion

### 3.1. Land Use Pattern of the Study Area

The major land use pattern of Charghat Upazila of Rajshahi district has been categorized into following classes: agricultural land, orchard, infrastructural land, water bodies, fallow land, char land, and river area. Total land area of Charghat Upazila 16458 ha. Of this, Agricultural land is 7718 ha, Orchard land 4610 ha, Infrastructure 2711 ha, Water bodies 524.64 ha, Char land 430 ha, and River area 340.48 ha, respectively.

### 3.2. Orchard Land Pattern

The study area are generally characterized by relatively high acreage of orchard land as it comes from data since 1995 to 2018. The area of orchard land was mainly covered by the various fruits. The most predominating fruits in this area was mango where exclusive fruits base pattern occupied by 83% (Figure 1). The second dominate fruits pattern in Charghat Upazila was Jackfruits 4% and rests were litchi, guava, banana, coconut, *etc*. (Figure 1). Due to over cultivation of mangoes the area under cultivation of other fruits is decaling and also production is reduced.

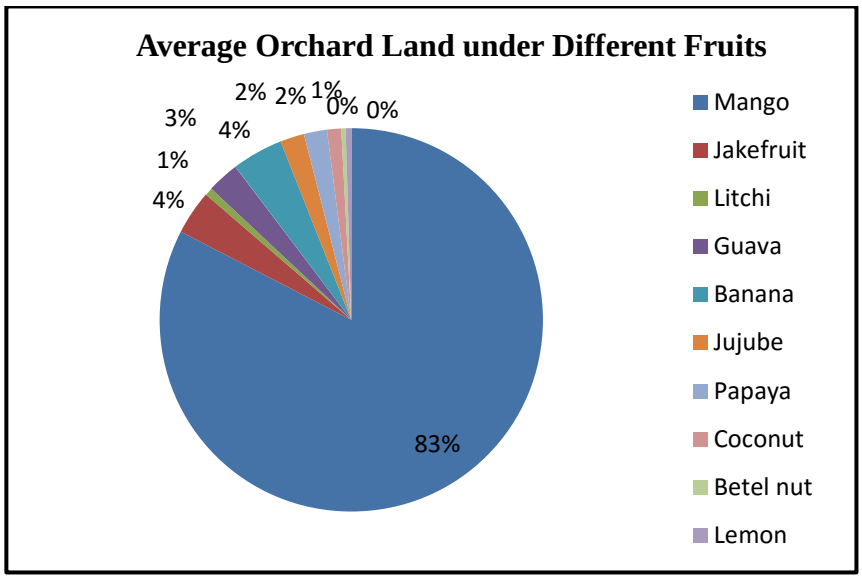



Figure 1. Orchard Cultivation Pattern in the Study Area

### 3.3. Orchard Based Cropping Pattern

Orchard cropping pattern are diversified in the area. Figure 2 shows the major orchard-based cropping pattern revels that pulses- Fallow- wheat (27%), Sugarcane-Fallow- Pulses (23%) and Vegetable-Fallow- Pulses (15%) patterns were dominant and others patterns were recessive.

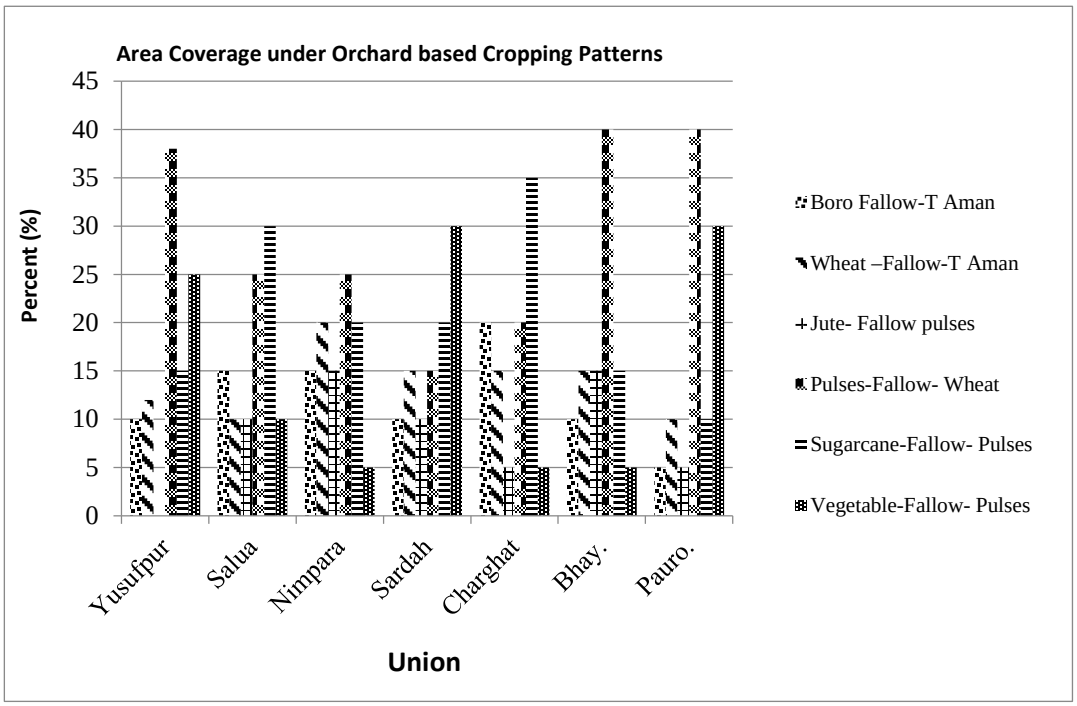



Figure 2. Orchard base Cropping Patterns in the Study Area

### 3.4. Land Conversion

Land conversion is a process which characterized by converting the land from one type of use to another. It is generally claimed that in Bangladesh every year over 80,000 ha of agricultural land *i.e.* nearly one percent a year (Planning Commission 2009) is being converted to non-agriculture. This is too meager an amount for the country's food security as the productivity of land in Bangladesh is also low (Quasem, 2011). It was

observed that in the study area, agricultural land has been decreased by 26.72(%) during the last 25 years at a rate 1.06%, which was more that national level. This trend suggest that the agricultural land is converting to other types of land use, especially mango orchard. Figure 3 shows that every year the agricultural land decreased gradually. The decreasing rate almost the same except in 1998 -99 and 2017-18, where the highest decreased was in 1998-99 and lowest decreased in 2017-18 in the study area. The rises of land conversion continue almost in the same way till 2019. Similar trend also found by DAE, 2018 while Orchard land increased sharply 27.92 (%) and a rate 1.01(%) in the area.

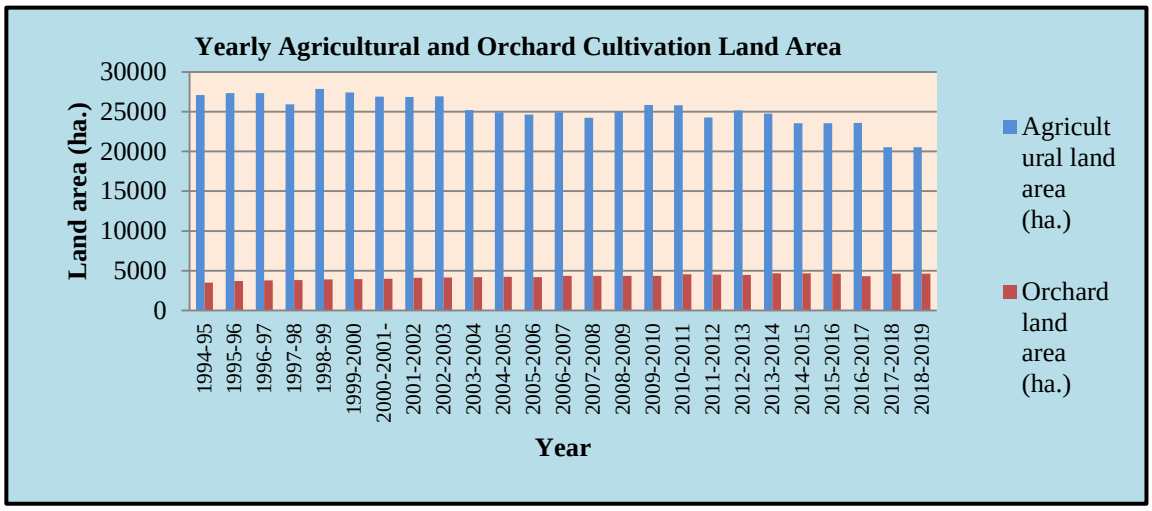



Figure 3. Yearly Agricultural and Orchard Land Pattern in the Study Area

### 3.5. Cost and Return for Crop Production

Financial profitability of crop production was examined on the basis of gross margin (GM) analysis. Farmers allocated their land and other resources in crop production on the basis of land suitability, relative financial profitability and family needs. It also depends on prices of the products, cost of production and availability of production technologies. Table 1 shows the details of financial profitability of crop production or gross margin of crops grown in the study area. In Charghat Upazila region, non-rice crops were more profitable (BCR non rice wheat 0.61, jute 1.18, pulses 1.07, sugarcane 2.25 and vegetable 2.41) than rice crops (BC Rrice, 1.06). Similar results by Sarker *et al.*, 2014 showed that non-rice crops were more profit (BCR ranged from 1.20 to 2.02). Another researchers work on comparative profitability crops to mango cultivation observed that net return from mango cultivation was 75% higher than other cropping patterns by Khandaker *et al*., 2017. The present study observed that agricultural production was decreased gradually and orchard production was more than previous time.

Table 1. Gross margin (Tk/ha) for Rice and Non-Rice Crops under Orchard-Based Patterns

| Crops | Yield(t/ha) | Sale Price (Tk/ha) | Total Variable cost (TVC) (Tk/ha) | Gross Return (GR) (Tk/ha) | Gross Margin (GM=GR-TVC) ( Tk/ha) | Undiscounted BCR=GR/TVC |
|---|---|---|---|---|---|---|
| Charghat Upazila | | | | | | |
| Paddy | 2.70 | 15 | 220000 | 234200 | 14200 | 1.06 |
| Wheat | 4.13 | 20 | 294500 | 182200 | -112300 | 0.61 |
| Jute | 1.33 | 35 | 80000 | 94000 | 14000 | 1.18 |
| Pulses | 5.33 | 30 | 200000 | 215000 | 15000 | 1.07 |
| Sugarcane | 2.00 | 05 | 195000 | 439000 | 244000 | 2.25 |
| Vegetable | 0.33 | 35 | 7200 | 17400 | 10200 | 2.41 |

### 3.6. Cost and Return for Mango Orchard Cultivation

During the study period, farmer's perception about cost mango cultivation was collected. As farmer's in the study area were much interested in mango cultivation, it is common opinion that mango is highly profitable crop. Thus farmer are willing to mango cultivation for higher profit. The highest increased in the study area was recorded for mango (83%) cultivation (Figure 1).Cost of production includes variable items like land preparation, human labour, sapling, manures, fertilizer, bamboo stick, insecticides, *etc*. Both cash expenditure and imputed value of family supplied inputs were also included in the analysis. Total cost of mango cultivation is varied among the years. The results shows that the average higher production cost (Tk 54500/ha) was observed in 1st quarter (year 1-3) followed by Tk 12000/ha in 2nd quarter (year 4-6) followed by Tk 9800/ha. Similar cost trend was observed in all union and Charghat Pauroshava. Table 2 also presented the return from mango cultivation, while in the 1st year, farmers did not get any return. Mango farmers usually start getting yield from the 2nd year of cultivation and obtained on average 103 kg/ha mango yield in 1st quarter (year 1-3) and then production sharply reached to 21694 kg/ha in 5th quarter (year 13-15). Almost similar trend was found in Charghat Upazila where the highest gross return of mango was found in 5th quarter in all locations, and the BCR of $1^{st}$, $2^{nd}$, $3^{rd}$, $4^{th}$and $5^{th}$ quarters were 0.21, 3.28, 8.46, 9.15 and 9.95, respectively in Charghat area. The result indicates that increasing life span of mango orchard increases the profitability (Table 2). The analysis reveals that mango cultivation is more favorable, suitable and economically profitable for mango farmer. Similar results obtained by Sarker *et al.*, 2014 in their study: In Barind tract crop land shifting mango orchard average higher production of mango cost Tk 47003/ha was observed in $1^{st}$ quarter followed by Tk 27983/ha in $2^{nd}$ quarter 106432/ha in Tanore, Godagariand Gomastapur area. Comparably the highest gross return of mango was found $5^{th}$ quarter which were Tk 101358/ha Tanore, 106432/ha Godagari and 109408/ha Gomastapur respectively. The BCR of $1^{st}$, $2^{nd}$, $3^{rd}$, $4^{th}$ and $5^{th}$ quarters were 0.20,2.05, 3.19, 4.40 and 5.20 respectively. However in previous study comparative profitability to mango cultivation was observed by Khandaker *et al*., 2017 and the average total cost of mango cultivation was Tk 1.33,889 per hectare, while higher cost was Tk 1,52,010 in the $16^{th}$-$20^{th}$ year. The average of mango was yield found to be the highest in $16^{th}$-$20^{th}$ year 26.48 ton/ha and the BCR 2.89. It is observed that higher productivity of lands which were highly profitable and prompted the farmers to go converted land for production of mango orchard. Table 3 shows the details for year-wise cost and return estimation of mango orchard and agro-physiological information.

Table 2. Cost and Return (Tk/ha) Analysis for Mango Cultivation

| Items | Life Span of Mango Orchard (Year) | | | | |
|---|---|---|---|---|---|
| | $1^{st}$ quarter (1-3) | $2^{nd}$ quarter (4-6) | $3^{rd}$ quarter (7-9) | $4^{th}$ quarter (10-12) | $5^{th}$ quarter (13-15) |
| **Charghat Upazila** | | | | | |
| Yield(kg/ha) | 103 | 1296 | 5503 | 14369 | 21694 |
| Sale price(Tk/kg) | 25 | 25 | 25 | 25 | 25 |
| Total return(Tk/ha) | 2575 | 32400 | 137592 | 359239 | 542371 |
| Total cost(Tk/ha) | 12000 | 9866 | 16250 | 39250 | 54500 |
| Gross return(Tk/ha) | -9425 | 22134 | 121342 | 319989 | 487871 |
| BCR | 0.21 | 3.28 | 8.46 | 9.15 | 9.95 |

### 3.7. Agro-physiological Information

Physiological characteristics like canopy coverage (% of shading area), crops yield loss (%) due to shading and land loss (%) due to pit formation are showing in Figure 3. Increasing life span of mango orchard increases yield loss of both rice and non-rice crops. In 15-year-old mango decreases intercrop yield (90%) indicating that

intercrop production was not economically profitable. Similar result was observed by Sarker *et al.*, 2014, while in 11-year-old mango orchard, intercrop yield reduced drastically (65%).

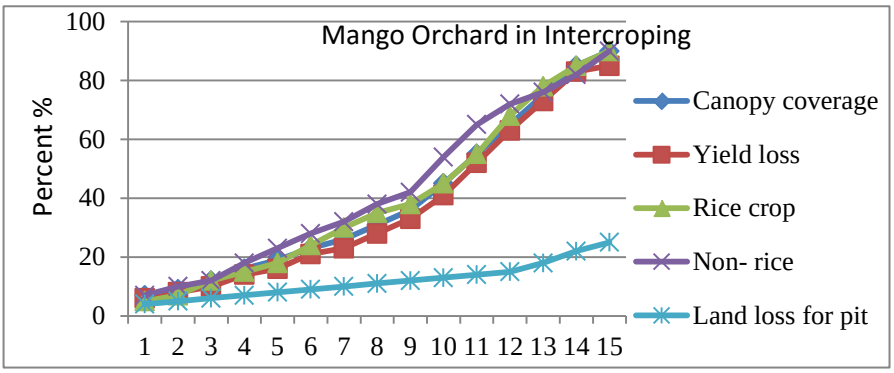



Figure 4. Agro- Physiological Information of Mango in the Study Area

### 3.8. Reasons for Mango Orchard Cultivation

Orchard cultivation was perceived by the farmer as economically profitable and environment friendly, and it also enhances house-hold food security as well as social status of farmers those have converted crop land into mango orchard cultivation due to favorable agro-ecological condition. The mango orchard farmers were elaborated their cultivated area for mango orchard cultivation. They also reported that they might increase orchard area next year. Among all the responded, mango farmers opined that increasing their cultivable area for mango orchard due to scarcity of water and favorable climate for mango orchard cultivation. They also reported that converted their cultivable areas for mango orchard in coming years because it is highly profitable enterprise 83% and its cultivation process is easy 67%. About 70% farmers stated that they want to increase area because they have suitable orchard land 70% and favorable environment 71% for orchard cultivation (Table 4). Crop land converted to mango cultivation is economically suitable, environmentally friendly and ensure household food security of the mango farmers (Kowsari *et al*., 2014). In recently, in the study area, mango farmers cultivated malta and dragon fruits with the help of neighboring farmer and technique of cultivation from Department of Agricultural Extensions (DAE) worker. This cultivation they promoted subsequently due to more profit than mango cultivation.

Table 4. Reasons for Increasing Orchard Cultivation

| Items | % Respondent Farmer | | | | | | | All Locations |
|---|---|---|---|---|---|---|---|---|
| | Yusuf pur | Salua | Nimparaara | Sardah | Charghat | Byaluxmpur | Paurohava | |
| High profitable | 90 | 92 | 90 | 91 | 94 | 94 | 92 | 92 |
| Higher economic value | 80 | 84 | 80 | 82 | 87 | 94 | 84 | 84 |
| Easy cultivation process | 90 | 92 | 90 | 91 | 94 | 87 | 92 | 91 |
| Inter cropping | 70 | 84 | 80 | 82 | 87 | 80 | 84 | 81 |
| Climate change/ water scarcity | 90 | 75 | 80 | 73 | 80 | 87 | 75 | 80 |
| Availability suitable orchard land | 80 | 67 | 70 | 64 | 74 | 74 | 75 | 71 |
| Favorable environment for orchard land | 70 | 84 | 80 | 73 | 74 | 74 | 67 | 75 |
| Needs less labour | 90 | 92 | 90 | 91 | 94 | 94 | 92 | 92 |

### 3.9. Impact of Orchard Cultivation

Orchard cultivation has created remarkable impact on farmer income. About 91% farmers mentioned positive impacts on household income, food intake and livelihoods improvement due to convert of crop lands to mango orchards (Table 5). More than 92% farmers obtained increased income and about 77% achieved better livelihoods. Otherwise farmer was reported that in the long run orchard cultivation may decrease when it production are available and they not achieved better profit for livelihood.

Although mango orchard is a profitable crop, there are some constraints to its higher production. The first and foremost obedience to orchard cultivation were lack of technological support and training 77% followed by disease and insect infestation 92%. As orchard tree plantation in crop land is a new idea, many of the farmers were not trained about the technology of cultivation. Orchard cultivation required higher cost, especially in 1st year. Therefore, some marginal and small farmers were not able to cultivate this crop, although they were very much enthusiastic to cultivate it. Lack of transport facilities 92% and marketing facilities 77% were other constraints to orchard cultivation. Whereas farmer also reported that in the long run, orchard cultivation may decrease both rice and non-rice land 80% and thus lead to decrease food grain, pulses, oil seed and vegetables production 72%, which may threaten food security in the area (Table 5).

Table 5. Impact of Orchard Cultivation on Farm Income, Livelihood and Food Security

| Items | % Respondent Farmer | | | | | | | All Locations |
|---|---|---|---|---|---|---|---|---|
| | Yusufpur | Salua | Nimpara | Sardah | Charghat | Bhayalak | Paurosh ava | |
| Positive impact | 90 | 92 | 90 | 91 | 94 | 94 | 92 | 91 |
| Negative impact | 10 | 08 | 10 | 09 | 06 | 06 | 08 | 8 |
| Types of positive impact | | | | | | | | |
| Increase in household income | 90 | 92 | 90 | 91 | 94 | 94 | 92 | 92 |
| Increase in livelihoods | 70 | 75 | 80 | 73 | 80 | 87 | 75 | 77 |
| Increase in food production/intake | 80 | 67 | 70 | 64 | 74 | 74 | 75 | 72 |
| Less water requirement | 70 | 84 | 80 | 73 | 74 | 74 | 67 | 75 |
| Types of negative impact | | | | | | | | |
| Decrease food grin/pulses/oil seed/vegetable production | 80 | 67 | 70 | 64 | 74 | 80 | 67 | 72 |
| Decrease non rice land | 90 | 75 | 80 | 73 | 80 | 87 | 75 | 80 |

## 4. Conclusions

The study evaluates the suitability and profitability of mango orchard in comparison to crops cultivation. The result concluded that mango orchard cultivation required higher cost in primary stage. It received higher net return as well as BCR compared to other crops. This situation motivate farmers attitude towards for mango orchard cultivation. Mango orchard is more profitable which enhance income for local farmers and increasing their economic development and social status. Major constraints to mango cultivation such as diseases and insect's infestation, lack of training, credit and marketing facilities are insufficient. Same farmers also reported that increasing orchard area may decrease rice and non-rice production. Especially, the conversion of land to orchard will be continued. So, government should take necessary steps for planned mango orchard cultivation for retaining crop land for food grain and ensured the credit facilities for orchard cultivation, preservation and marketing.

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Table 3. Cost Return (Tk/ha) Analysis for Mango Cultivation

| | **Life span of Mango Orchard (Year)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| YusufpurUnion | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 70 | 180 | 480 | 2200 | 3200 | 4400 | 6000 | 7500 | 9600 | 12000 | 13500 | 16500 | 19500 | 22500 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 1750 | 4500 | 12000 | 55000 | 80000 | 110000 | 150000 | 187500 | 240000 | 300000 | 337500 | 412500 | 487500 | 562500 |
| Total cost(tk/ha) | 37500 | 8500 | 8500 | 10500 | 20250 | 22500 | 24000 | 26250 | 30200 | 37500 | 41250 | 45000 | 48750 | 52500 | 60000 |
| Grossreturn(tk/ha) | -37500 | -3750 | -6750 | .-6000 | 71250 | 157500 | 86000 | 123750 | 157300 | 202500 | 258750 | 292500 | 363750 | 435000 | 502500 |
| BCR | 0 | 0.2 | o.53 | 1.14 | 2.71 | 3.55 | 4.58 | 5.71 | 6.2 | 6.4 | 7.27 | 7.5 | 8.46 | 9.28 | 9.37 |
| SaluaUnion | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 110 | 220 | 350 | 530 | 1500 | 2700 | 3800 | 5200 | 6500 | 7800 | 9500 | 12500 | 16500 | 19500 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 2750 | 5500 | 8750 | 13250 | 37500 | 67500 | 95000 | 130000 | 162500 | 195000 | 237500 | 312500 | 412500 | 487500 |
| Total cost(tk/ha) | -35500 | 7250 | 7500 | 4200 | 8500 | 12000 | 16500 | 20250 | 22500 | 24000 | 26250 | 30200 | 37500 | 41250 | 45000 |
| Grossreturn(tk/ha) | -35500 | -4500 | -2000 | 4550 | 4750 | 25500 | 51000 | 74750 | 107500 | 138500 | 168750 | 207300 | 275000 | 371250 | 442500 |
| BCR | 0 | o.38 | o.73 | 1.o6 | 1.55 | 3.12 | 4.09 | 4.69 | 5.77 | 6.77 | 7.43 | 7.86 | 8.33 | 10 | 10.83 |
| NimparaUnion | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 75 | 150 | 205 | 385 | 465 | 585 | 750 | 1450 | 3200 | 5500 | 9600 | 13700 | 16500 | 19500 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 1875 | 3750 | 5125 | 9625 | 11625 | 14625 | 18750 | 36250 | 80000 | 137500 | 240000 | 342500 | 412500 | 492500 |
| Total cost(tk/ha) | 38400 | 8200 | 8200 | 8500 | 8500 | 8800 | 9400 | 9400 | 10500 | 12000 | 16500 | 20250 | 22500 | 24000 | 26250 |
| Grossreturn(tk/ha) | -38400 | -6325 | -4450 | -3375 | 1125 | 2825 | 5225 | 9350 | 25750 | 68000 | 121000 | 219750 | 320000 | 388500 | 466250 |
| BCR | 0 | 0.29 | o.45 | 0.6 | 1.13 | 1.32 | 1.55 | 1.99 | 3.45 | 6.66 | 8.33 | 11.85 | 15.22 | 17.18 | 18.76 |
| Sardah Union | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 80 | 180 | 450 | 780 | 1600 | 3100 | 5800 | 9800 | 14800 | 19500 | 21700 | 23500 | 24700 | 27000 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 2000 | 4500 | 11250 | 19500 | 40000 | 77500 | 145000 | 245000 | 370000 | 487500 | 542500 | 587500 | 617500 | 675000 |
| Total cost(tk/ha) | 34500 | 7700 | 8500 | 8500 | 9000 | 10500 | 15000 | 28000 | 33750 | 37500 | 39000 | 41250 | 43500 | 48750 | 52500 |
| Grossreturn(tk/ha) | -34500 | -5700 | -4000 | 2750 | 10500 | 29500 | 62500 | 117000 | 211250 | 332500 | 448500 | 501250 | 544000 | 568750 | 622500 |
| BCR | 0 | 0.26 | 0.52 | 1.32 | 2.17 | 3.8 | 5.16 | 5.16 | 7.26 | 9.87 | 12.5 | 13.15 | 13.5 | 12.66 | 12.85 |
| CharghatUnion | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 90 | 240 | 600 | 3000 | 4500 | 6000 | 9600 | 12000 | 13500 | 16500 | 19500 | 21000 | 22500 | 2400 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 2250 | 6000 | 15000 | 75000 | 112500 | 150000 | 240000 | 300000 | 337500 | 412500 | 487500 | 525000 | 526500 | 600000 |
| Total cost(tk/ha) | 36500 | 7500 | 7500 | 9000 | 18750 | 22500 | 24000 | 26250 | 37500 | 41250 | 45000 | 48750 | 51000 | 52500 | 60000 |
| Grossreturn(tk/ha) | -36500 | -5250 | -1500 | 6000 | 56250 | 90000 | 126000 | 213750 | 262500 | 296250 | 367500 | 438750 | 474000 | 474000 | 540000 |
| BCR | 0 | 0.3 | 0.8 | 1.66 | 4 | 5 | 6.25 | 9.15 | 8 | 8.18 | 9.16 | 10 | 10.29 | 10.02 | 10 |
| ByaluxmpurUnion | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 112.5 | 400 | 750 | 1450 | 1950 | 3200 | 5500 | 9500 | 16500 | 22500 | 2400 | 25600 | 27000 | 28500 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 2812 | 10000 | 18750 | 36250 | 48750 | 80000 | 137500 | 237500 | 412500 | 526500 | 600000 | 637500 | 675000 | 712500 |
| Total cost(tk/ha) | 36500 | 7500 | 7800 | 9400 | 9700 | 10500 | 12000 | 16500 | 20250 | 28500 | 37500 | 48750 | 50500 | 52500 | 55500 |
| Grossreturn(tk/ha) | -36500 | -4688 | 2200 | 9350 | 26550 | 38250 | 68000 | 121000 | 217250 | 384000 | 489000 | 551250 | 587000 | 622500 | 657000 |
| BCR | 0 | o.37 | 1.28 | 1.99 | 3.73 | 4.64 | 6.66 | 8.33 | 11.72 | 14.47 | 14.04 | 12.3 | 12.62 | 12.86 | 12.84 |
| CharghatPauroshara | | | | | | | | | | | | | | | |
| Yield(kg/ha) | 0 | 80 | 180 | 450 | 780 | 1600 | 3100 | 5800 | 9800 | 14800 | 19500 | 21700 | 23500 | 24700 | 27000 |
| Sale price(tk/ha) | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Total return(tk/ha) | 0 | 2000 | 4500 | 11250 | 19500 | 40000 | 77500 | 145000 | 245000 | 370000 | 487500 | 542500 | 587500 | 617500 | 675000 |
| Total cost(tk/ha) | 34500 | 7700 | 8500 | 8500 | 9000 | 10500 | 15000 | 28000 | 33750 | 37500 | 39000 | 41250 | 43500 | 48750 | 52500 |
| Gross return(tk/ha) | -34500 | -5700 | -4000 | 2750 | 10500 | 29500 | 62500 | 117000 | 211250 | 332500 | 448500 | 501250 | 544000 | 568750 | 622500 |
| BCR | 0 | 0.26 | 0.52 | 1.32 | 2.17 | 3.8 | 5.16 | 5.16 | 7.26 | 9.87 | 12.5 | 13.15 | 13.5 | 12.66 | 12.85 |
| | Agro-Physiological InformationofMango Orchard (year) in CharghatUpozila | | | | | | | | | | | | | | |
| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Canopy coverage (%) | 7 | 9 | 12 | 16 | 19 | 23 | 26 | 31 | 36 | 45 | 55 | 65 | 75 | 85 | 90 |
| Yield loss (%) | 6 | 8 | 10 | 14 | 16 | 21 | 23 | 28 | 33 | 41 | 52 | 63 | 73 | 83 | 85 |
| Rice crop | 5 | 7 | 12 | 15 | 18 | 24 | 30 | 35 | 38 | 45 | 55 | 68 | 78 | 85 | 90 |
| Non- rice | 7 | 10 | 12 | 18 | 23 | 28 | 32 | 38 | 42 | 54 | 65 | 72 | 76 | 82 | 90 |
| Land loss (%) for pit | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 18 | 22 | 25 |

# Potentiation of Burmese Pink Cassia *Cassia renigera* Benth Extracts against Brine Shrimp Nauplii *Artemia salina* (L.) and *Lymnaea acuminata* Lamarck

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## Abstract

Pet. (Petroleum) ether, $CHCl_3$ (Chloroform) and $CH_3OH$ (Methanol) extracts of leaves and stem-bark of *Cassia renigera* Benth. were evaluated against brine shrimp *Artemia salina* (L.) nauplii and *Lymnaea acuminata* Lamarck adults through cytotoxicity and molluscicidal activity tests. Except the Pet. ether extract of leaves all the rest were found effective. Against *A. salina* nauplii the *C. renigera* leaves gave $LC_{50}$ values 428.54, 315.20, 240.30, 180.20, 163.22 and 126.54 ppm for the $CHCl_3$ extract and 528.90, 358.21, 270.70, 192.56, 195.63 and 140.20 ppm for the $CH_3OH$ extract after 18, 24, 30, 36, 42 and 48 h of exposure respectively. The stem bark gave $LC_{50}$ values 536.23, 339.43, 271.56, 192.56, 186.58 and 140.20 ppm for Pet. ether extract; 662.82, 368.90, 283.48, 205.04, 189.97 and 156.85 ppm for $CHCl_3$ and 551.60, 368.90, 334.24, 233.07, 215.52 and 140.22 ppm for $CH_3OH$ extract, all after 18, 24, 30, 36, 42 and 48 h of exposure respectively. Against *L. acuminata* the *C. renigera* leaves gave $LC_{50}$ values 117.15, 103.30, 91.65, 66.74, 66.74, 52.12 and 49.35 ppm for the $CHCl_3$ extract, and 216.04, 177.94, 149.50, 111.61, 92.34, 59.43 and 52.20 ppm for the $CH_3OH$ extract; the stem bark gave $LC_{50}$ values 105.77, 140.07, 100.62, 95.48, 86.76, 71.47 and 66.40 ppm; 129.37, 111.72, 96.67, 85.28, 77.66, 78.82 and 77.70 ppm, and 134.76, 107.35, 102.26, 94.21, 83.25, 80.70 and 77.00 ppm for Pet. ether, $CHCl_3$ and $CH_3OH$ extracts after 12, 18, 24, 30, 36, 42 and 48 h of exposure respectively.

**Keywords:** Potentiation; *Cassia renigera*; Extracts; *Artemia salina*; *Lymnaea acuminata.*

## 1. Introduction

*Cassia renigera* Benth belongs to the Family- Caesalpinaceae. It mainly grows throughout the tropical countries. It is commonly known as Burmese Pink Cassia. The genus *Cassia* consists of nearly 1000 species and *C. renigera* is one of the remarkable species among them (Rahman, 2013; Jain and De Filipps, 1991). It is a small tree less than 20 feet in height. In May, when the large, impressive flowers, as well as green leaves and tenders appear, it looks like an amazingly gorgeous picture, heightened by the varied characters of pink in each of the clusters (Pawar and Mello, 2011). In traditional medicine, numerous medicinal properties of *C. renigera* have been recognized from time to time. Among them, sennosides are well known to the people for having remarkable medicinal values (Raghunathan *et al.*, 1974). Extracts of different *Cassia* species have been used as remedy for rheumatic disease, skin ailments and as laxatives (De Filipps, 1991; Hooker, 1879; Bhakta *et al.*, 1999). The leaf and seed extracts have been found to possess significant hepatoprotective activity and anti-inflammatory activity (Hossain *et al.*, 2018; Nesa *et al.*, 2017; Yadav *et al.*, 2013; Maity and Dinda, 2003; Asolkar, 1992). Previously, the plant has been examined for identifying its antifeedant, larvicidal, antioxidant, antitumour, anti-inflammatory and antimicrobial activities against different test agents (Gupta, 2000; Luximon-Ramma *et al.*, 2002; Raju *et al.*, 2005; Aneja *et al.*, 2011; Duraipandiyan *et al.*, 2011). High potential mortality has been recorded against different stored grain pests and also found to be proficient in controlling grain damages and seed weight loss (Weaver and Subramanyam, 2000; Sabbour, *et al.*, 2007). Many synthetic pesticides have been introduced in the recent time to control agricultural, veterinary, medical and household insect pests. But due to the voluminous and iterative use of synthetic pesticides have attributed so many pernicious effects on the environment and also occur intoxication to non-target organisms (Gupta *et al.*, 2001). So, at present special emphasize has been given to the probable use of botanicals or plant products as promising substitutes to chemical insecticides in controlling insect pests (Khalequzzaman and Islam, 1992; Ohazurike *et al.*, 2003; Umoetok and Gerard, 2003; Abdelouaheb *et al.*, 2009). This intimation has created a worldwide interest in the development of alternative recipe, including the

discovery of fresher insecticides (Dayan *et al.,* 2009). In this investigation, leaves and stem-barks of the plant *C. renigera* have been taken into consideration to find out the cytotoxic effects against *Artemia salina* and molluscicidal activity against *Lymnaea acuminata*.

## 2. Materials and Methods

### 2.1. Collection and Preparation of Test Materials

Fresh leaves and stem-barks of the Burmese Pink Cassia *C. renigera* were collected separately from the Botanical Garden of the University of Rajshahi, Bangladesh. Identification of the target plant was confirmed by the experts on plant taxonomy in the Department of Botany, University of Rajshahi, Bangladesh. Collected plant materials were cleaned properly with the help of a brush and sliced into small pieces. The chips were spread out on wooden-tray to dry. This was done at room temperature under shade avoiding direct sunshine. The materials were rearranged thrice daily to avoid heaping. It needed 10 to 15 days to ready for grinding. Then the plant materials were powdered in an electric grinder machine avoiding additional heat during grinding. The ground materials were placed separately into conical flasks to add solvents in a proportion of 10:1 as solvent and plant dust materials sealed in conical flask (250 ml) to keep on a shaker for 48 h. The Pet. ether, $CHCl_3$ and $CH_3OH$ (Merck, Germany) were used (200 g × 600 mL × 2 times) successively while each of which kept 48 h on a shaker. For each of the extracts filtration was done by using filter paper at 24 h interval in the same flask followed by evaporation until the extract was left as a scum. The extracts were removed to glass vials and preserved in a refrigerator at 4°C with proper labeling.

### 2.2. Collection and Culture of Test Insects

The test agent *Artemia salina* nauplii were emerged from the cysts released in a beaker containing salty water. The nauplii were hatched from the cysts within a period of 24h of age. Another test agent, adult snails of *Lymnaea acuminata* were collected from the nearby ponds and low-lying submerged areas in the Rajshahi University Campus. The collected snails were reared in pond water in an aquarium under laboratory conditions for the continuous supply of snails of same size and age during experimentation.

### 2.3. Brine Shrimp Lethality Test

First of all, the test tubes were filled with 10 ml of water and marked the lower meniscus with a marker pen and the tubes were made empty. Then, the doses were prepared at five different concentrations in the test tubes by adding a calculated amount of DMSO (dimethylsulfoxide) with the extracts in order to make them hydrophilic prior to add half of the required amount of water in each. The nauplii were counted by visual inspection and were released in each of the test-tubes with the help of a pipette; the additional amount of water was added to fill the test tubes up to the pre-marked level containing 10 ml of water including the test-tube considered as a control batch. Observation of mortality was made after 18, 24, 30, 36, 42 and 48 h of exposure. Doses for all three extracts (Pet. ether, $CHCl_3$ and $CH_3OH$) were 200, 400 and 600 ppm, respectively.

### 2.4. Molluscicidal Activity Test

From the aquarium culture adult *L. acuminata* snails were collected. In each of the 50 ml beakers ten individuals were kept. Test samples at different concentrations considered as doses were prepared in beakers by adding calculated amount of DMSO (Dimethylsulfoxide) to make them hydrophilic before adding half of the required amount of water in each. After that a certain amount of pond water was added to fill up the pre-marked beakers with the help of a pipette. The snails were counted by visual inspection and were released in the beakers containing 10 ml of water. Observation of mortality was made after 12, 18, 24, 30, 36, 42 and 48 h of exposure with an interval of 6 h. After experimenting pilot doses, the final applicable doses for leaf extracts were fixed as 50, 60 and 70 ppm; for stem-bark extracts the fixed doses were 70, 80 and 90 ppm. All the experiments were carried out in the Crop Protection & Toxicology Laboratory of the Department of Zoology, University of Rajshahi, Rajshahi-6205, Bangladesh.

### 2.5. Statistical Analysis

The mortality (%) was corrected using Abbott's formula (Abbott, 1925). The data were then subjected to Probit analysis by using GW Basic software (Busvine, 1971; Finney, 1947).

## 3. Results

### 3.1. Brine Shrimp Lethality Test

The $CHCl_3$ and $CH_3OH$ extracts of leaves and Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of stem-bark were found effective against brine shrimp *A. salina* nauplii. The $LC_{50}$ offered by the $CHCl_3$ and $CH_3OH$ extracts of the leaves and the Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of the stem-bark of *C. renigera* against *A. salina* nauplii are represented in Table 1.

Table 1. $LC_{50}$ values offered by the extracts of *C. renigera* against *A. salina* nauplii

| Plant parts | Extract solvent | $LC_{50}$ (ppm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 18h | 24h | 30h | 36h | 42h | 48h |
| Leaf | $CHCl_3$ | 428.54 | 315.20 | 240.30 | 180.20 | 163.22 | 126.54 |
| | $CH_3OH$ | 528.90 | 358.21 | 270.70 | 192.56 | 195.63 | 140.20 |
| Stem-bark | Pet. ether | 536.23 | 339.43 | 271.56 | 192.56 | 186.58 | 140.20 |
| | $CHCl_3$ | 662.82 | 368.90 | 283.48 | 205.04 | 189.97 | 156.85 |
| | $CH_3OH$ | 551.60 | 368.90 | 334.24 | 233.07 | 215.52 | 140.22 |

### 3.2. Molluscicidal Activity Test

All extract samples were found effective against *L. acuminata* except Pet. ether extract of leaves. The $LC_{50}$ offered by the $CHCl_3$ and $CH_3$ OH extracts of leaves and Pet. ether, $CHCl_3$ and $CH_3$ OH extracts of stem-bark of *C. renigera* against *L. acuminata* are showed in Table 2.

Table 2. $LC_{50}$ values offered by the extracts of *C. renigera* against *L. acuminata*

| Plant parts | Extract solvent | $LC_{50}$ (ppm) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 12h | 18h | 24h | 30h | 36h | 42h | 48h |
| Leaf | $CHCl_3$ | 117.15 | 103.30 | 91.65 | 66.74 | 66.74 | 52.12 | 49.35 |
| | $CH_3$ OH | 216.04 | 177.94 | 149.50 | 111.61 | 92.34 | 59.43 | 52.20 |
| Stem-bark | Pet. ether | 105.77 | 140.07 | 100.62 | 95.48 | 86.76 | 71.47 | 66.40 |
| | $CHCl_3$ | 129.37 | 111.72 | 96.67 | 85.28 | 77.66 | 78.82 | 77.70 |
| | $CH_3$ OH | 134.76 | 107.35 | 102.26 | 94.21 | 83.25 | 80.70 | 77.00 |

### 3.3. Discussion

The outcomes of the present study get support from the previous experiments done on *C. renigera* and its related species by researchers, however works on *C. renigera* for the detection of biological activity viz. dose mortality, repellency, cytotoxicity, feeding deterrent activity, antibactertial and antifungal activity, etc. The antioxidant, antimicrobial and brine shrimp lethality action of *C. renigera* has revealed by an investigation (Hossain *et al.*, 2015). The effectiveness of its relative species, *C. siamea* leaf extract against mosquito larvae was explored by determining the lethal concentration, $LC_{50}$ that are almost similar with the result of this present study (Jiraungkoorskul and Jiraungkoorskul, 2015). The present study exposes that aqueous *C. renigera* leaf and stem-bark extracts have insecticidal potentials. Some of the close species have been investigated to reveal their potentials of *C. cuminum* seed and *C. siamea* leaf showed 100% mortality against *C. quinquefasciatus* and *A. stephensi* after 48h of exposure (Kamaraj, 2011). *C. tora* showed significant anti-inflammatory activity against acute rat paw edema (Maity *et al.*, 1998). The anti-inflammatory and anti-nociceptive properties of *C. spectabilis*

were assessed by an investigation (Da Silva *et al.,* 2012). *C. auriculata* extract exposed antioxidant properties both *in vitro* and *in vivo* conditions (Juan-Badaturuge *et al.,* 2011; Rajagopal *et al.,* 2003). Additional studies discovered that the *C. auriculata,* a relative species of *C. renigera,* have antihyperlipidemic effect (Gupta *et al.,* 2009; Gupta *et al.,* 2011).

## 4. Conclusion

After analyzing the results of this investigation and considering the outcome the previous works done on *C. renigera* and its relative species, it could be concluded that further developments on the secondary metabolites of this could be used in the pest control strategy. Further investigation should be taken into consideration to explore the exact compound for which this plant extracts show pesticidal effect.

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# Vector Control Potentials of *Mentha piperita* L.

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## Abstract

The whole plant (wp) of *Mentha piperita* L. was extracted in petroleum ether (Pet. ether), chloroform ($CHCl_3$) and methanol ($CH_3OH$), and were screened through dose-mortality and repellency tests against eggplant aphid, *Aphis gossypii* and only dose-mortality assay against larvae of the mosquito, *Culexquinque fasciatus* under laboratory conditions. Against *A. gossypii* for Pet. ether extract the $LD_{50}$ values were 0.235, 0.189, 0.158, 0.136, 0.111, 0.093, 0.083 and 0.070 mg $cm^{-2}$; for $CHCl_3$ 0.252, 0.198, 0.189, 0.156, 0.130, 0.107, 0.103 and 0.095 mg $cm^{-2}$; and for $CH_3$ OH extracts 0.412, 0.332, 0.345, 0.328, 0.258, 0.208, 0.156 and 0.126mg $cm^{-2}$ at different exposure hours. Against *A. gossypii* the $CHCl_3$ and $CH_3$ OH extracts offered repellent activity at 5% ($P<0.05$) and 1% ($P<0.01$) level of significance, while the Pet. ether extract of the same did not show repellency for aphids. In the 2nd dose-mortality assay of the same extracts one day old mosquito larvae also responded to the same extracts giving $LD_{50}$ values 174.072, 114.399, 79.776, 60.519 and 46.065 ppm for Pet. ether extract, 418.844, 229.226, 183.390, 130.911 and 97.375 ppm for $CHCl_3$ extract, and 1195.342, 1075.135, 696.966, 516.804 and 309.859 ppm for $CH_3$ OH all for 6, 12, 18, 24 and 30h of exposures respectively. The analysis of data revealed that the test plant *M. piperita* possesses vector control potentials since the test agents are all vectors.

**Keywords:** *Mentha piperita*; dose-mortality; repellency; larvicidal activity; *Aphis gossypii; Culexquinque fasciatus* larvae

## 1. Introduction

First warning signals about pesticides' danger appeared in 1962 (Carson, 1962), an American courageous woman and scientist, wrote down her nature observation and pointed out sudden dying of birds caused by indiscriminate spraying of pesticides (DDT, half-life of it in soil ranges from 22 to 30 years). Her book, Silent Spring, became a landmark. It changed the existing view on pesticides and has stimulated public concern on pesticides and their impact on health and the environment. Pesticides represent the only group of chemicals that are purposely applied to the environment with an aim to suppress pests of plants and animals and to protect agricultural and industrial products. However, the majority of pesticides are not specifically targeting the pests, they also affect non-target organisms. Thus, repeated application of pesticides leads to loss of biodiversity (Pesticide Action Network, 2010). The use of pesticides by Bangladeshi farmers increased by 328 percent during the past 10 years, posing a serious health hazards on human being due to its long-term residual effect, according to a study released by Bangladesh Rice Research Institute (Islam, 2010). The extensive use of synthetic inorganic insecticides have resulted in environmental hazards. Vector is an organism, often an invertebrate arthropod that transmits a pathogen from reservoir to host. Viruses that are transmitted between vertebrate or plant hosts by feeding insects (vectors) can replicate within both their host and their vector. Plant viruses pose some of the most severe threats to world agriculture. Because they invade the crop's cells and cloak themselves with the plant's normal life processes. More than half of the nearly 550 vector-transmitted virus species recorded so far are disseminated by aphids 55% and by beetles 11% (Astier *et al*., 2001). Aphid or plant louse is a tiny, usually green, soft-bodied, pear-shaped insect injurious to vegetation. They vary in length from 1 to 10 millimeters. Aphids feed themselves through sucking mouthparts called stylets. Some are wingless, others have two pairs of transparent or colored wings.

Mosquitoes are important vector responsible for the pathogens of various diseases like malaria, filariasis, Japanese encephalitis (JE), dengue and dengue haemorrhagic fever, yellow fever, etc. There are four common groups of mosquitoes living in the Bay Area. They are *Aedes*, *Anopheles*, *Culex*, and *Culiseta*. The mosquitoes are a family of the Culicidae. Although a few species are harmless or even useful to humanity, most are

considered nuisance because they consume blood from living vertebrates, including humans. Some authorities argue accordingly that mosquitoes are the most dangerous animals on Earth (Michigan Mosquito Control Organization, 2013).

Plant is a natural source for providing mankind various secondary metabolites with antiviral or vector control activity, which are organic compounds. The present investigation was carried out to find out the vector control potential of *Mentha piperita* L (=*Convolvulus nummularius* L.), against the eggplant aphids and *Culex quinque fasciatus* larvae. It is a perennial herb with prostrate stem, often pilose at the nodes with short tricomes to glabrate. It binds the ground while creeping around (Ahmed *et al*., 2009). The whole plant is used as a medicine for hysteria, to cure burns, cuts, wounds and scropion stings (Jain, 1991). In Nepal, the paste of the plant is used to treat scabies (Manandhar, 2002). This plant can be seen on the hill slopes, edges of fields, roadsides and railway embankments. It is widely distributed in India, Nepal, Bhutan, tropical America and Africa. In Bangladesh, it is found in all districts. This medicinal plant was targeted for biological activities by many previous researches detected antioxidant activity (Haydari *et al.,* 2019), biological activity (Alexa *et al.,* 2018; Brahmi *et al.,* 2017), antibacterial and antifungal activity (Al-Rajab *et al.*, 2018; Giri *et al.*, 2007; GökalpİşcanI *et al.,* 2002), antibacterial and antioxidental activity (Singh *et al.,* 2015). It also improved their biological activity of elevated $CO_2$ induced metabolic change in basil (Jaouni *et al.,* 2018).

## 2. Materials and Methods

### 2.1. Collection and Preparation of Test Materials

*M. piperita* was collected from the Rajshahi University campus, identified and kept in the herbarium of the Department of Botany, University of Rajshahi. The plants were chopped into small pieces, dried under shade and powdered using a hand grinder, weighed and placed in separate conical flasks to add Pet. ether, $CHCl_3$ and $CH_3OH$ (Merck, Germany) (100 gm × 300 ml × 2 times) for 48 h. Filtration was done by Whatman filter paper (made in USA) at 24h interval in the same flask followed by evaporation until the extract was left. The extracts was then removed to glass vials and preserved in a refrigerator at 4°C with proper labeling.

### 2.2. Collection and Culture of Test Insect

Aphids are highly reproducing insects. At first some mature aphids were collected from affected plants and then released on the new fresh eggplants for further production. They multiply in a good number within a short time. Aphids were collected repeatedly from the culture field with a fine camel hair-brush in a Petri dish and used in the experiments. Mosquito eggs were hatched in stagnant water. They are collected from damp drains with special collecting spoon. Collected mosquito egg-rafts were placed into a new beaker containing pond water and kept it in a dark place inside the lab for hatching. After 24 h, hatched larvae were collected from the hatching tank and used in the experiment.

### 2.3. Dose-mortality Tests

#### 2.3.1. Dose-mortality Test on Eggplant Aphids

For aphids instead of Petri dish fresh eggplant laves were used. Fresh eggplant leaves were collected and placed on a Petri dish. Stalks of each of the leaves were wetted with water soaked cotton to keep them fresh. The leaves were made round (3.6 cm diam.) in shape by a pair of scissors near the stalks. With the help of a CD marker a round circle was drawn. Extract was applied on both the sides of the round shaped leaves with the help of a 1 ml syringe. The concentrations used in this experiments were 0.196, 0.147, 0.098, 0.049, 0.025 mg $cm^{-2}$ for Pet. ether, $CHCl_3$ and $CH_3OH$ extracts, respectively. Three replicates for each of the extracts were maintained. After application of the extractives the leave circles were allowed to dry out as exposed in the air for 30-45 minutes. Then ten insects were released in the middle of each circle. The mortality of the aphids was assessed after 3, 6, 9, 12, 15, 18, 21 and 24h of exposure.

**2.3.2. Statistical Analysis:** The mortality (%) was corrected using Abbott's formula (Abbott, 1925):

$$P_r = \frac{P_o - P_c}{100 - P_c} \times 100$$

Where, $P_r$ = Corrected mortality (%), $P_o$ = Observed mortality (%), $P_c$ = Control mortality (%). The data were then subjected to Probit analysis according to Finney (1947) and Busvine (1971).

### 2.4. Repellent Activity

The repellency test was adopted from the method (No. 3) of McDonald *et al*. (1970) with some modifications. A general concentration for each of the plant extracts was selected as stock dose for repellency and other successive doses were prepared by serial dilution to give 0.393, 0.197, 0.098, 0.049 and 0.025 mg $cm^{-2}$ concentrations for the extracts. Ten aphids were released in the middle of each of the leaf circle. Insects that settled on each of the non-treated half of the circles were counted after 1 h and then observed repeatedly at hourly intervals for five hours. The orientation was changed in the two remaining replicates to avoid the effects of any external directional stimulus affecting the distribution of the test insects. The average of the counts was converted to percent repellency (*PR*) using the formula of Talukder and Howse (1993, 1995): $PR = (Nc - 5) \times 20$, where, Nc is the percentage of insects on the untreated half of the circles.

### 2.5. Larvicidal Activity Test

Mosquito rafts (eggs) were collected from the different drains of Rajshahi University then placed into a new beaker containing normal pond water and kept in a dark place inside the laboratory to hatch. After 24 hours, hatched larvae were collected and used in the experiment. The series of doses were 200, 100, 50, 25, 12.5 and 6.25 ppm; 400, 200, 100, 50, 25 and 12.5 ppm; and 800, 400, 200, 100, 50 and 25 ppm for Pet. ether, $CHCl_3$ and $CH_3OH$ extracts respectively. Ten freshly hatched larvae were added to each of the test tubes with different concentrations mentioned earlier and mortality was observed after 6, 12, 18, 24 and 30 h of exposure. The data was subjected to Probit analysis.

## 3. Results and Discussion

### 3.1. Dose Mortality Effects on Eggplant Aphids

The dose-mortality results of Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of *M. piperita* are represented in Table 1. The Pet. ether extract offered highest mortality giving $LD_{50}$ values ranged between 0.235 to 0.070 mg $cm^{-2}$. For the $CHCl_3$ extract $LD_{50}$ values ranged between 0.252 to 0.095 mg $cm^{-2}$ and for the $CH_3OH$ extract $LD_{50}$ values ranged between 0.412 to 0.126 mg $cm^{-2}$ against the eggplant aphids. The efficacy of the extracts could be arranged in a descending order of Pet. ether extract> $CHCl_3$ extract> $CH_3OH$ extract of the test plant.

Table 1. $LD_{50}$ values of Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of *M. piperita* against eggplant aphids, *A. gossypii*.

| Solvents | $LD_{50}$ (mg $cm^{-2}$) at different exposures (in hours) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3h | 6h | 9h | 12h | 15h | 18h | 21h | 24h |
| Pet. ether | 0.235 | 0.189 | 0.158 | 0.136 | 0.111 | 0.093 | 0.083 | 0.070 |
| $CHCl_3$ | 0.252 | 0.198 | 0.189 | 0.156 | 0.130 | 0.107 | 0.103 | 0.095 |
| $CH_3OH$ | 0.412 | 0.345 | 0.332 | 0.328 | 0.258 | 0.208 | 0.156 | 0.126 |

### 3.2. Repellent Effects on Eggplant Aphids

The $CH_3OH$ extracts of *M. piperita* offered a moderate repellent effect against eggplant aphids at levels of significance $P<0.01$ and the $CHCl_3$ extract offered a mild repellent effect against eggplant aphids at levels of significance $P<0.05$; while the Pet. ether extract did not offer any significant repellency among the doses (Tables 2 and 3).

Table 2. Percent repulsion values and the arcsine transformed data of the Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of *M. piperita* against eggplant aphids, *A. gossypii*.

| Solvent | Dose mg/cm$^{-2}$ | Percent repulsion PR = (Nc – 5) × 20 in hours (arcsine transformed values for ANOVA) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Pet. ether | 0.393 | 80 (63.43) | 80 (63.43) | 66.6 (54.70) | 73.4 (58.90) | 60 (50.77) |
| | 0.197 | 66.6 (54.70) | 53.4 (46.95) | 53.4 (46.95) | 66.6 (54.70) | 53.4 (46.95) |
| | 0.098 | 80 (63.43) | 80 (63.43) | 66.6 (54.70) | 73.4 (58.90) | 100 (90) |
| | 0.049 | 80 (63.43) | 93.4 (75.11) | 60 (50.77) | 73.4 (58.90) | 73.4 (50.77) |
| | 0.025 | 80 (63.43) | 86.6 (68.53) | 46.6 (43.05) | 86.6 (58.90) | 73.4 (58.90) |
| $CHCl_3$ | 0.393 | 40 (39.23) | 73.4 (58.90) | 86.6 (68.53) | 73.4 (58.90) | 86.6 (68.53) |
| | 0.197 | 80 (63.43) | 93.4 (75.11) | 80 (63.43) | 86.6 (68.53) | 86.6 (68.53) |
| | 0.098 | 80 (63.43) | 66.6 (54.70) | 86.6 (68.53) | 73.4 (58.90) | 80 (63.43) |
| | 0.049 | 66.6 (54.70) | 60 (50.77) | 66.6 (54.70) | 80 (63.43) | 73.4 (58.90) |
| | 0.025 | 6.6 (14.89) | 40 (39.23) | 40 (39.23) | 53.4 (46.95) | 60 (50.77) |
| $CH_3OH$ | 0.393 | 40 (39.23) | 46.6 (43.05) | 46.6 (43.05) | 33.4 (35.30) | 46.6 (43.05) |
| | 0.197 | 73.4 (58.90) | 86.6 (68.53) | 100 (90) | 86.6 (68.53) | 86.6 (68.53) |
| | 0.098 | 40 (39.23) | 66.6 (54.70) | 53.4 (46.95) | 66.6 (54.70) | 73.4 (58.90) |
| | 0.049 | 20 (26.57) | -20 (26.57) | 13.4 (21.47) | 26.6 (31.05) | 20 (26.57) |
| | 0.025 | 33.4 (35.30) | 40 (39.23) | 33.4 (35.30) | 46.6 (43.05) | 60 (50.77) |

Table 3. Repellency effect of Pet. ether, $CHCl_3$ and $CH_3$ OH extracts of *M. piperita* against the eggplant aphids, *A. gossypii*.

| Solvents | Between doses (df =4) | | Between time interval (df=4) | |
|---|---|---|---|---|
| | F-values | Level of significance | F-values | Level of significance |
| Pet. ether | 2.183051 | | 1.800319 | - |
| $CHCl_3$ | 10.06319* | P<0.05 | 2.691459 | - |
| $CH_3OH$ | 28.19058** | P<0.01 | 1.377064 | - |

### 3.3. Larvicidal Activity Effect

The larvicidal activity for Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of *M. piperita* represented in Table 4. The Pet. ether extract offered the highest activity with $LC_{50}$ values ranged between 174.072 to 46.065 ppm, followed by the $CHCl_3$ extract with $LC_{50}$ values between 418.844 to 97.375 ppm and for the $CH_3$ OH extract with $LC_{50}$ values 1195.342 to 309.859 ppm all for 6, 12, 18, 24 and 30h of exposures respectively.

Table 4. $LC_{50}$ values of Pet. ether, $CHCl_3$ and $CH_3OH$ extracts of *M. piperita* against the *C. quinquefasciatus* larvae.

| Solvents | $LC_{50}$ (ppm) at different exposures (in hours) | | | | |
|---|---|---|---|---|---|
| | 6h | 12h | 18h | 24h | 30h |
| Pet. ether | 174.072 | 114.399 | 79.776 | 60.519 | 46.065 |
| $CHCl_3$ | 418.844 | 229.226 | 183.390 | 130.911 | 97.375 |
| $CH_3OH$ | 1195.342 | 1075.135 | 696.966 | 516.804 | 309.859 |

The results receive supports from many previous findings. Karanja extract treated plants had minimal rate of incidence of viral infestation, with maximum plant height, flower production, fruit formation and highest yield (Bhuyan *et al.*, 2007). Neem extract generally recorded low aphid populations and an average fewer plants infected with symptoms of viral infestation (Singh and Korpraditskul, 1999). According to Das *et al*., 2008 aphidicidal activity of hot and cold water extracts of some indigenous plants were tested against the bean aphid, *Aphis craccivora* Koch. Hot water extract of *Po. hydropiper* and *A. indica* were found to be the most effective (87.6 - 94.5 and 80.47 - 89.6% mortality respectively, $P < 0.01$) among all the extracts.

Essential oil from the leaves of *L. camara* was reported to possess adulticidal activity against *Aedes aegypti*, *C. quinquefasciatus*, *Anopheles culicifacies*, *An. fluvialitis* and *An. stephensi* (mosquitoes) with $LD_{50}$ values 0.06, 0.05, 0.05, 0.05 and 0.06mg/cm$^2$ (Dua, *et al*., 2010). Mosquito larvicidal assays through methanol and ethanol extracts of leaves and flowers of *L. camara* exhibited significant activity against 3$^{rd}$ and 4$^{th}$ instar larvae of *Ae. aegypti* and *C. quinquefasciatus* (Kumar and Maneemegalai, 2008). According to Bucker *et al*. (2013) $CH_3OH$ extracts showed higher activity against *A. nuneztovari* larvae than against *A. aegypti* larvae, suggesting that the extracts have species-specific activity. Gallardo *et al.* (2011) showed that essential oils (EOs) from *Tagetes lucida*, *Lepechinia betonicifolia*, *Lippia alba*, *Cananga odorata*, and *Rosmarinus* were repellent, followed a dose-response relationship and EOs from *C. odorata* and *L. alba* were the most active repellents against *T. castaneum. Pramanik et al. (2009) observed that* the F values of the arcsine transformed data were 60.983, 14.177, 19.437, 15.429 and 1.082 respectively for the repellency against *T. castaneum* adults for $CHCI_3$ extracts of leaf, stem bark, stem wood, root bark and root wood extracts of *Glycosmis pentaphylla*. Except for the root wood extract, strong repellent activity was observed for the rest of the extracts (P<0.001). Chloroform and ethanol extract of Bishkatali showed strong repellency against *T. castaneum* (like that of the mortality results) where chloroform extract was better than ethyl alcohol extract (Kundu *et al.*, 2007). It was observed that Biskatali (leaf/water extract) have shown strong repellent and feeding deterrent effect followed by Nishinda and Pithraj (Islam *et al.*, 2000).

Thus, a comprehensive phytochemical analyses of the *M. piperita* for its insecticidal, repellent and larvicidal components, as well as the physiological studies of the active ingredients is very much to be solicited for their effective use in the future vector control and pharmaceutical endeavors.

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# Assessment of Heavy Metals in Some Fruit Samples from Local Market in Rajshahi City, Rajshahi, Bangladesh

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## Abstract

Rajshahi is a populous city. Most of the people consume fruits from city market. Therefore, it has been designed to collect in different fruits samples from city market site. This study assessed the levels of selected heavy metals (lead, chromium, cadmium, and arsenic) in some fruits samples of commonly consumed from the Rajshahi city market, Rajshahi. The present work was designed and carried out for findings of the heavy metal concentrations and identifying health risk index in some selected fruits. A total of twenty-three samples were collected for analysis randomly from Rajshahi city market. Samples were wet digested using a mixture of 1:3 (65% HCl : $HNO_3$) and analysed using Atomic Absorption Spectrophotometer version AA-6300 and coupled with an auto-sampler ASC -6100. The results of this study showed that the concentrations detected ranged from 1.867 to 44.337, 0.442 to 1.506, 0.002 to 0.063, 0.019 to 0.252 mg/kg for Pb, Cr, Cd, and As respectively. The highest concentration levels of Pb were detected in karanda. The highest concentration levels of Cr were detected in strawberry. From the examined samples will pose no risk as they remain below than the recommended limit for these elements except eight fruits samples (guava, banana, indian olive, karanda, mango (lokhna and lengra), strawberry, pine apple) in terms of lead and chromium. From the results of health risk index, the population is therefore at no risk of Pb, Cr, Cd and As.

**Keywords:** RCM (Rajshahi City Market); Heavy metals; Target hazard quotient; Hazard index.

## 1. Introduction

Fruits are an inevitable and important part of a healthy and balanced diet. They could be contaminated by heavy metals in many ways including irrigation by sewage water and industrial effluents sewage sludge, vehicular emissions, industrial waste and atmospheric deposition. Fruits have been recognized as good sources of vitamins and minerals, and for their role in preventing vitamin C and vitamin A deficiencies. People who eat fruits as part of an overall healthy diet generally have a reduced risk of chronic diseases. Fruits and vegetables are edible plant products that are good for health. Precise qualitative and quantitative analyses of heavy metals present in them are important for accurate nutritional labeling, determination of compliance with the standard of identification and in ensuring that the products meet manufacturer's specification. Vegetables and fruits useful for the maintenance of health, important sources of many nutrients and the prevention and treatment of various diseases. However, plants may contain both essential and toxic metals over a wide range of concentrations. Heavy metals have been reported to have positive and negative roles in human health because the body needs a low level of few metal concentrations. If this level exceeds the effect become negative Some heavy metals like cadmium, lead, chromium, arsenic are major contaminants of food and might be considered the most deleterious problem to our environment while others like iron, zinc and copper are essential for biochemical reactions in the body.

Heavy metals have damaging effects on humans and animals because of their non-biodegradable nature, long biological half-lives and potential to accumulate in different body parts as there is inadequate mechanism for their elimination from the body (Jarup et al., 2003). Accumulation of heavy metals has been reported to exhibit carcinogenic, mutagenic and teratogenic effects (Marco et al., 2013). Pb and Cd are the most abundant heavy metals and their excessive intake is associated with cardiovascular, kidney, nervous and bone diseases (Marco et al., 2013**,** Radwn et al., 2006). Children are at particular risk to the harmful side effects of food adulteration, which may lead to serious liver and kidney diseases including various forms of cancer and hepatitis (Kurtoglu et al., 2007).

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It is reported that Bangladeshi foodstuffs showed relatively high concentration of heavy metals grown in different regions of Bangladesh (Alam et al., 2003). Having reliable database on contamination levels in commonly consumed fruits for elucidating the present status of heavy metal contamination and ensuring food safety is very important. The present work was designed and carried out for detecting some of toxic metals and find those elements for their concentrations in some selected fruits that were mostly sold in Rajshahi Central City Market called Sahib bazaar. Identifying the exportable fruits were free from or within the permissible limits of heavy metals concentration. The health risk assessment associated with heavy metals (Pb, Cr, Cd and As) of fruit locally grown, estimated exposure and risk index were calculated. Monitoring and assessment of heavy metals in foodstuffs from market sites have been carried out in some developed and developing countries (Marco et al., 2013).

## 2. Materials and methods

### 2.1. Materials

All reagents were analytical grade (AR) and purchased from Merck, Germany. A calibrated electrical balance (GR-200, A&D Company Limited, Tokyo, Japan) with high precession was used for weighing purpose. Calibrated glass wares including pipette and volumetric flask were used for sample preparations. They were soaked in 10% (v/v) $HNO_3$ overnight and rinsed with deionized water and dried prior using.

### 2.2. The Study Area

Rajshahi district is a district in north-western Bangladesh. It is a part of the Rajshahi division. The metropolitan city of Rajshahi in Rajshahi district. Geographically Rajshahi is situated within brind tract, 23 m (75 ft) above sea level & lies at 24°22′26″ N 88°36′04″ E. The city is located on the alluvial planes of the Padma river, which runs through southern side of the city. It is bounded on the east, north and west by Paba upazila (subdivision of a district) of the district. The study area is located at zero point (local name sahib bazaar) of Rajshahi district. Shopping mall are located close to this area. It is the focal point of main Rajshahi town. There is a mosque close to it known as sahib bazaar mosque which is located on the junction of natore road.

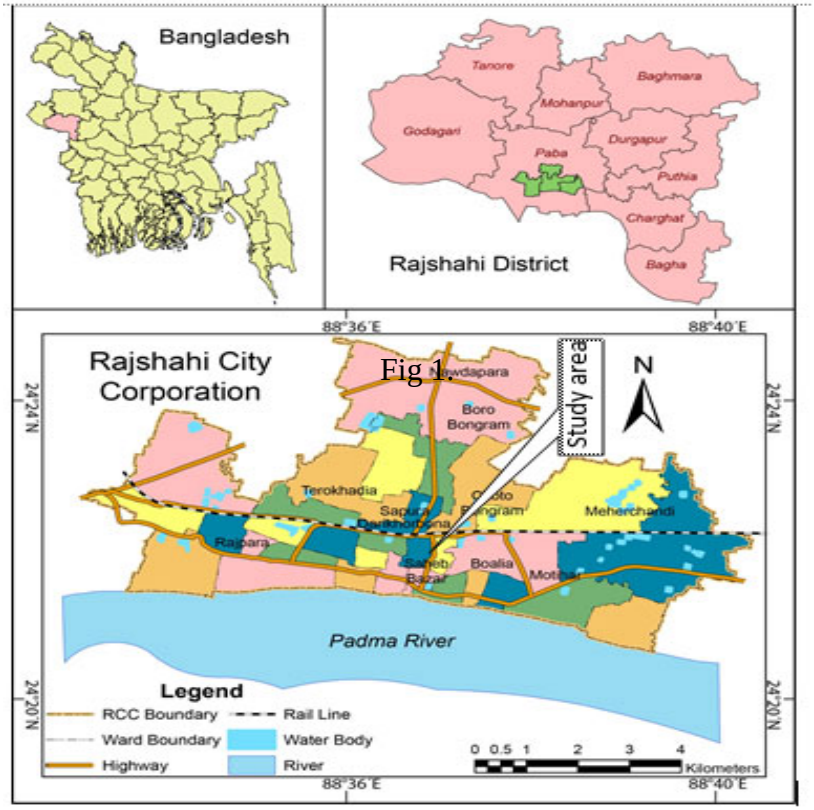


Fig 1.

Figure 1. Location of the research area

Table 1 English names and scientific names of analyzed fruits samples

| English Name | Scientific Name | Local name | Sample ID |
|---|---|---|---|
| Mango Gopalvog | *Mangifera indica* | Gopalvog Am | MG |
| Mango Fazlee | *Mangifera indica* | Fazlee Am | MF |
| Mango Lokhna | *Mangifera indica* | Lokhna Am | ML |
| Mango Khirshapat | *Mangifera indica* | Khirshapat Am | MK |
| Mango Asshini | *Mangifera indica* | Asshini Am | MA |
| Mango Lengra | *Mangifera indica* | Lengra Am | MLE |
| Wood apple | *Aegle marmelos* | Bel | WA |
| Strawberry | *Fragaria ananassa* | Strawberry | ST |
| Indian jujube | *Ziziphus mauritiana* | Apple Kool | AK |
| Indian jujube | *Ziziphus mauritiana* | Bau Kool | BK |
| Papaya | *Carica papaya* | Pepe | PA |
| Guava | *Psidium guajava* | Peyara | GU |
| Pineapple | *Ananas comosus* | Anaros | PI |
| Banana | *Musa ca*vendishii | Sagor kala | BA |
| Jackfruit | *Artocarpus heterophyllus* | Katal | JA |
| Sapodilla | *Manilkara zapota* | Sofeda | SA |
| Water melon | *Citrullus lanatus* | Tormuch | WM |
| Wax apple | *Syzygium samarangense* | Jamrul | WAP |
| Karanda | *Carissa carandas* | Koromcha | KA |
| Pomegranate | *Punica granatum* | Dalim | PO |
| Carambola | *Averrhoa carambola* | Kamranga | CA |
| Ceylon olive | *Elaeocarpus serratus* | Jolpai | CO |
| Muskmelon | *Cucumis melo* | Bangi | MU |

### 2.3. Collection and Preparation of Fruits Samples

All the seasonal fruit samples were purchased from the central city market of Rajshahi district during the month of February 2016 to January 2017. These fruits are grown in different parts of the country and transported to the city market for public consumption. Fruit samples were collected from the market in required amounts and rapped in paper bags and transported to the laboratory.

The samples were thoroughly cleaned first under tap water to elements dust, dirt, possible parasites or the eggs and then washed again with double distilled water (DDW). Non-edible parts were removed according to common household practices and the edible portion was chopped into small pieces. The small pieces of samples were dried in under sun. Then it dried an air dried oven at 90-95°C until a constant weight was obtained. The dried samples

were crushed in a grind machine and passed through an 85 mesh sieve. The resulting fine powder was stored in desiccators in the dark until digestion.

### 2.4. Health Risk Assessment

The health risk index was calculated as the ratio of estimated exposure of test fruit and oral reference dose (Cui et al., 2004). Oral reference doses were 0.0035, 1.5, 0.001 and 0.0003 mg $kg^{-1}$ $day^{-1}$ for Pb, Cr, Cd and As respectively (FAO/WHO, 2013) (USPEA-2013). Estimated exposure is obtained by dividing daily intake of heavy metals (DIM) by their safe limit. An index more than 1 is considered as not safe for human health (USEPA-2002)**.** Daily intake of heavy metals (DIM) was calculated by the following equation (Adedokun *et al*., 2016).

$$\mathrm{DIM} = \frac{\mathrm{C_{metal}} \times \mathrm{C_{factor}} \times \mathrm{C_{foodintake}}}{\mathrm{B_{average\ weight}}} \quad \text{.....(1)}$$

Where, $C_{metal}$ is the heavy metal conc. in fruit (mg/kg), $C_{factor}$ is the conversion factor; $C_{foodintake}$ is the daily intake of fruit. The conversion factor of 0.085 is to convert fresh fruit weight to dry weight (Sajjad et al., 2009) daily vegetable/fruit intake of 65 g/day (Ogunntona et al., 1998) while the average body weight used was 65 kg for this study (Ogunntona et al., 1998).

The health risk index (HRI) was calculated using the formula below in which RDF is a oral reference doses. (Adedokun et al., 2016).

$$\mathrm{HRI} = \frac{DIM}{\mathrm{RFD}} \quad \text{.....(2)}$$

### 6. Results and Discussion

Total lead concentration in all the fruits studied through AAS are shown in Table-2. The concentration are reported as milligrams of total lead per kilogram of edible parts of fruits (dry wt. basis). The maximum permissible limit of lead in foodstuffs is 7.2 mg/kg (dry wt. basis) (ANHMRC-1987). Karanda and indian olive exhibit highest Pb concentration in the fruits (44.337 mg/kg) and (42.713 mg/kg) followed by Guava (10.046 mg/kg), Banana (11.391 mg/kg) which exceeded the permissible limit of Pb. The concentration of Pb in fruits from central market of Rajshahi city was higher than the values of (0.05 - 24.9) mg/kg in seasonal fruits of Pakistan reported. (Jaffar *et al*., 2003, Tripathi *et al*., 1997) (Bombay city, India) have found the mean concentration of Pb in fruits 7.4 mg/kg and average level of Pb changed between 2.86 -1.54 mg/kg (Hamurcu *et al.*, 2010).

Results incorporated in Table-2, indicate that lead content in the studied fruit samples are ranged from 1.867 - 44.337 mg/kg. Among the analyzed fruits guava, banana, indian olive and karanda show a very level of lead i.e. 10.046, 11.391, 42.713 and 44.337 mg/kg respectively. The results are fairly comparable with these mentioned above. It is to be noted that guava, banana, indian olive and karanda show exceptionally higher Pb concentrations. It is concluded from the present results that the fruits under study except guava, banana, indian olive and karanda are safe for human consumption in terms of lead concentration. According to the national standard of China on Maximum Levels of Contaminants in Foods (ANHMRC-1987), maximum level for lead in fruits is 0.10 mg/kg. Availability of lead in fruits may be due to the use of ripening agents or due to the air surrounding the area is high in lead aerosol resulting from emission from automobile exhaust. The main sources of lead intake are foodstuffs like vegetables (up to 0.05 mg/kg), cereals and cereal products (up to 0.09 mg/kg), fruit and fruit juices as well as wine, beverages and drinking water (Hamuruc *et al.*, 2010).

Table 2 Concentration of heavy metals in fruits from RCM, Rajshahi.

| Sample ID | Heavy metal concentration in fruits samples (mg/kg) | | | |
|---|---|---|---|---|
| | Pb | Cr | Cd | As |
| MG | 2.518 | 0.654 | 0.007 | 0.070 |
| MF | 3.095 | 0.766 | 0.028 | 0.040 |
| ML | 3.092 | 1.019 | 0.006 | 0.037 |
| MK | 1.867 | 0.860 | 0.006 | 0.036 |
| MA | 4.258 | 0.647 | 0.007 | 0.252 |
| MLE | 2.533 | 1.277 | 0.009 | 0.019 |
| WA | 4.130 | 0.493 | 0.037 | 0.021 |
| ST | 4.588 | 1.506 | 0.037 | 0.039 |
| AK | 3.041 | 0.843 | 0.015 | 0.032 |
| BK | 3.133 | 0.865 | 0.063 | 0.034 |
| PA | 3.298 | 0.595 | 0.014 | 0.048 |
| GU | 10.046 | 0.728 | 0.026 | 0.059 |
| PI | 3.251 | 1.323 | 0.005 | 0.045 |
| BA | 11.391 | 1.323 | 0.008 | 0.043 |
| JA | 2.380 | 0.596 | 0.041 | 0.028 |
| SA | 2.756 | 0.638 | 0.020 | 0.035 |
| WM | 2.330 | 0.506 | 0.009 | 0.024 |
| WAP | 4.130 | 0.493 | 0.037 | 0.021 |
| KA | 44.337 | 0.621 | 0.013 | 0.036 |
| PO | 2.729 | 0.442 | 0.022 | 0.037 |
| CA | 3.052 | 0.875 | 0.025 | 0.036 |
| CO | 42.713 | 0.801 | 0.007 | 0.030 |
| MU | 5.138 | 0.827 | 0.029 | 0.022 |

The concentration distribution of Cr in fruits are given in Table-2. The result showed that chromium accumulated to greater or lesser extent by the 23 species investigated. The date presented in Table-2, revealed that the concentration of chromium are varied from 0.442 to 1.506 mg/kg. Maximum permitted concentration of chromium in foods is 1 mg/kg recommended by International/National standards for heavy metals in food. From the view point of public health, fruit consumption has been shown to be beneficial for well-being; studies have demonstrated that fruits reduce the risk of many chronic diseases (ANHMRC-1987). Cr (III) is poorly absorbed by any route, the toxicity of chromium is mainly attributable to the Cr (VI) form. It can be absorbed by the lung and gastrointestinal tract, and even to a certain extent by intact skin.

Chromium was found in almost all selected fruit varieties here, strawberry showed the highest chromium content (1.506 mg/kg) followed by mango lokhna (1.019 m/kg), mango lengra (1.277 mg/kg), banana (sagor) (1.070 mg/kg), pine-apple(1.323 mg/kg) and the lowest chromium content pomegranate (0.442 mg/kg), wax apple (0.493 mg/kg). The chromium content in fruit is comparable with the values reported in Bangladesh (2.5021 to 0.513 mg/kg) . (Narottam *et al.*, 2012).

Sajib, M. A. M. (Sajib et al., 2014) have observed the level of Cr, highest level is sapodilla, 0.062 ± 0.02 mg/100 g and lowest level is strawberry, 0.030 ± 0.01 mg/100g. According to the national standard of china on maximum levels of contaminants in foods**,** maximum level for chromium. The main sources of chromium are cereals, meat, vegetables and unrefined sugar, oil and fruits contain smaller amounts. Most foodstuffs contain chromium less than 0.1 mg/kg. Toxic aspects of chromium are related to Cr (VI), due to its high absorption, easy penetration of the cell membranes and its genotoxicity and oxidizing properties. The recommended intake of chromium is higher than actual values, however, a specific evaluation on chromium should be conducted including evaluation on the aspect of allergy and chromium as at least one reference refers to chromium allergy (Veien *et al*., 1994).

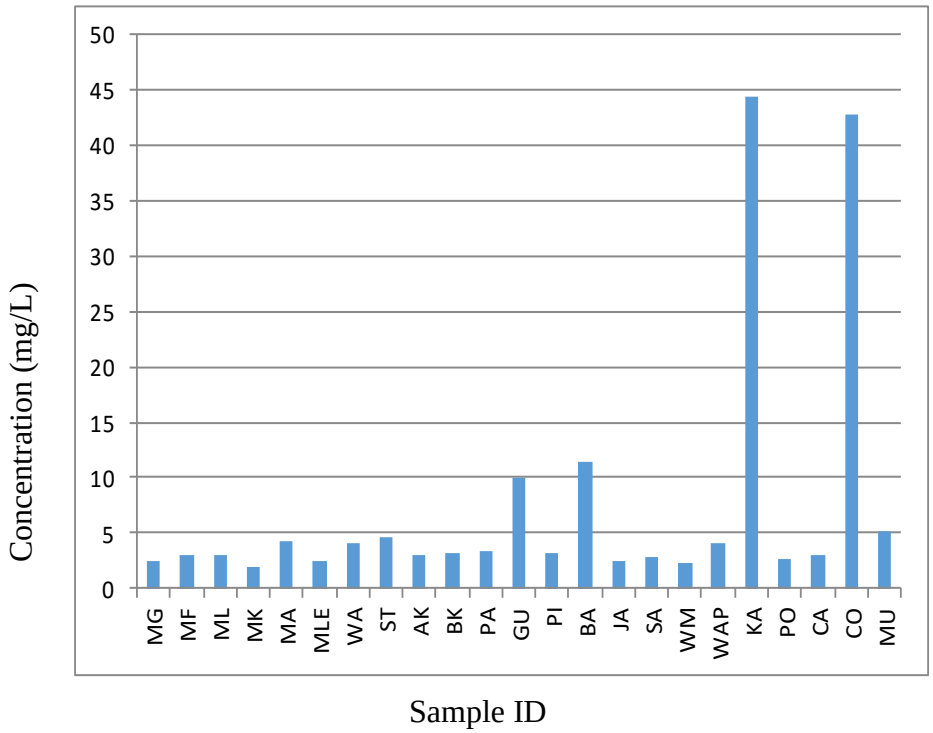


Figure 2. Indices of lead concentrations of fruit samples in RCM

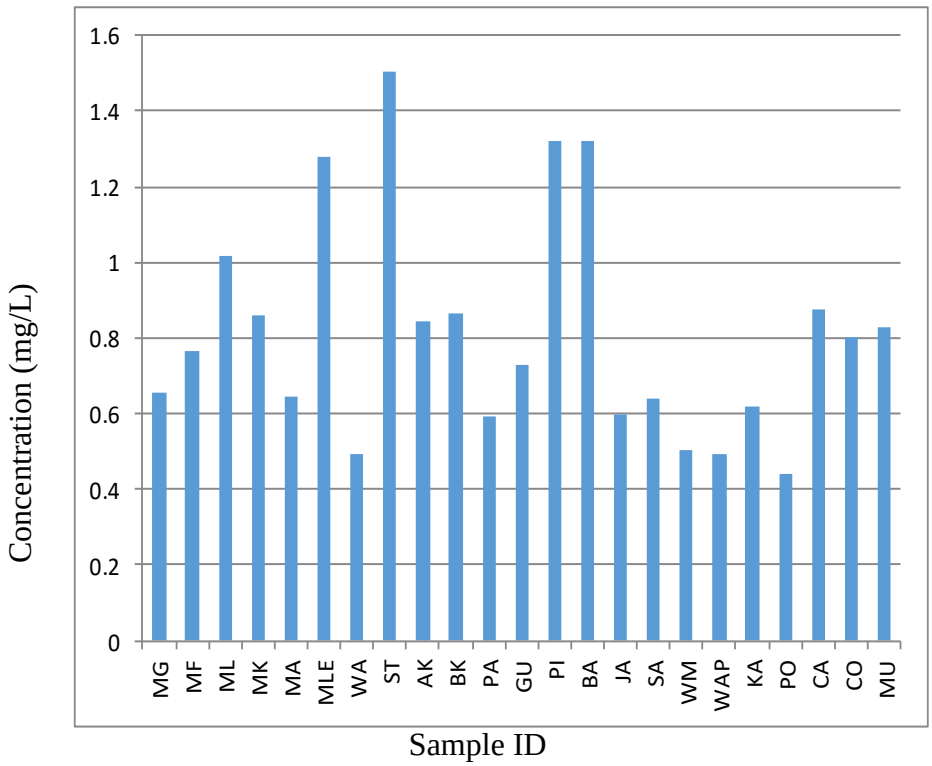


Figure 3. Indices of chromium concentrations of fruit samples in RCM

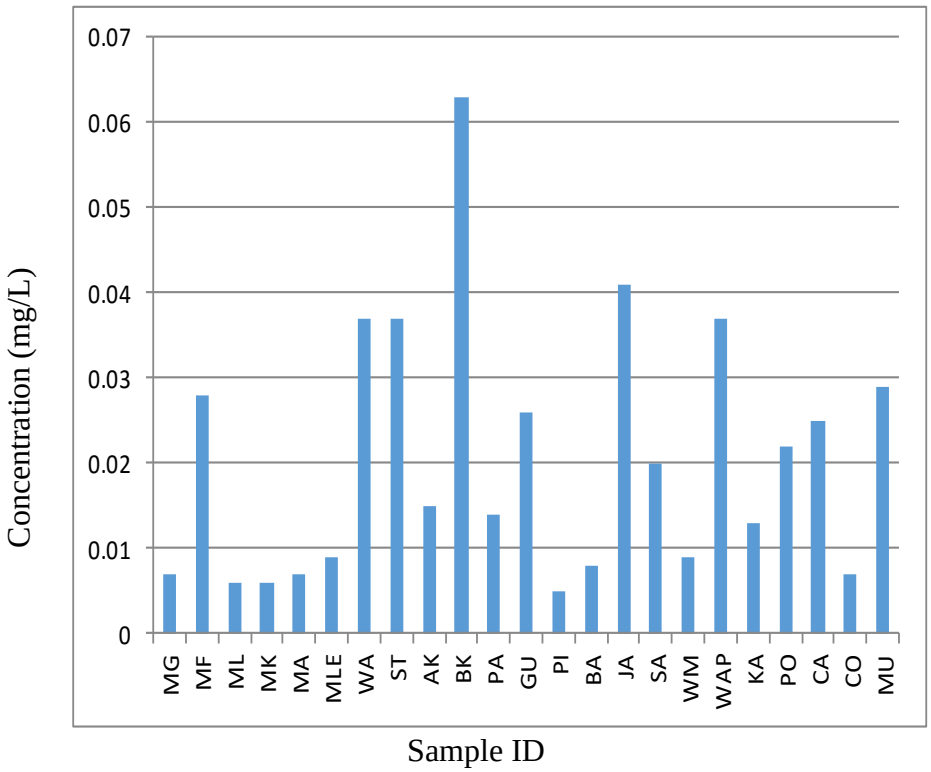


Figure 4. Indices of cadmium concentrations of fruit samples in RCM

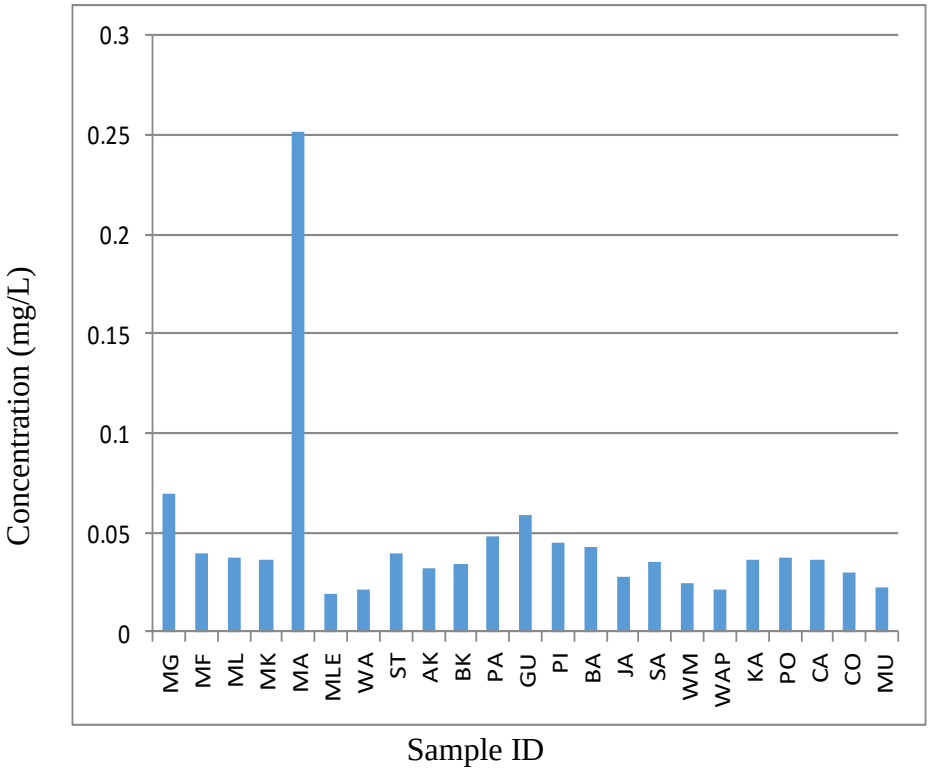


Figure 5. Indices of arsenic concentrations of fruit samples in RCM

The obtained results on total cadmium concentration from all fruit samples are summarized in Table-2 which is expressed as milligram of total cadmium per kilogram. From the Table-2, it is seen that the concentration of cadmium in fruit samples varied from 0.002 - 0.063 mg/kg. Maximum permitted concentration of cadmium in foods is 1 mg/kg recommended by International/National standards for heavy metals in food (YY Choi *et al*., 2011). The present results show that the concentration of total cadmium in collected fruit samples are within the normal limit. From these results one can infer that the fruits are free from cadmium and safe for human consumption.

From the investigation of some seasonal fruits in Pakistan. (Jaffar *et al*., 2003). It was found that cadmium concentration range from 0.05 (guava) to 7.31(mango) mg/kg for all fruits. Sajib, M. A. M. (Sajib *et al.*, 2014) have observed the level of cadmium of sapodilla, stone-apple and in tamarind fruit ranging from (0.046 ± 0.02 to 0.064 ±0.03 mg/100g). Narottam *et al.*, (2012) was found in Mango (3.02 mg/kg) while banana had the least concentration 0.585 mg/kg, this values were higher than the values (0.06-0.16 mg/kg) in some fruits grown at the roadsides of turkey reported (Hamurcu *et al*., 2010). The effects of cadmium on humans are nephrotoxicity, osteotoxicity, cardiovascular-toxicity and effects on reproduction and development and genotoxicity. Kidney damage also occurs as a result of cadmium exposure. Occasional peaks in cadmium intake may cause a drastic increase in fractional absorption of cadmium. Ingestion of highly contaminated foodstuffs results in acute gastrointestinal effects in form of diarrhea and vomiting. About 5% of ingested cadmium is absorbed**.** The speciation of cadmium in foodstuffs may be of importance for the evaluation of the health hazards associated with areas of cadmium contamination or high cadmium intake.

The total arsenic concentration in all the fruits studied are shown in Table-2. One can observe from the Table that the concentrations of As in fruit samples are ranged from 0.019 - 0.252 mg/kg. The result revealed that the highest concentration of As was observed in mango (asshini 0.252 mg/kg) and lowest were found in wood apple (0.019 mg/kg). The recommended and tolerance limits of arsenic in foodstuffs, water and soil are prescribed as 1.0 mg/kg, 0.05 mg/kg and 20 mg/kg respectively (Anon et al., 1987). The present results show that the

concentration of total As in collected fruit samples are within the normal limit. From these results one can infer that the fruits are free from As and safe for human consumption.

The studied of As content in fruit samples and among the fruits analyzed arsenic was found in Indian-gooseberry and strawberry ranging from 0.019 ± 0.01 µg to 0.105 ± 0.03 µg. (Sajib *et al.,* 2014). The highest amount of arsenic was found in strawberry, 0.105 ± 0.03 µg. Analysis of food and intake data from the U.S. department of agriculture continuing survey of food intakes by individuals indicates that the intake of arsenic for all age groups ranged from 0.50 to 0.81 µg/kg/day (Gunderson et al., 1991). Arsenic is an established human poison. Ingestion of doses greater than 10 mg/kg/day or greater can be accompanied anemia and hepatotoxicity (Fincher *et al.,* 1987).

Table 3. Health risk index (HRI) of heavy metals via intake of fruit analysed, RCM site, Rajshahi, Bangladesh.

| Sample | HRI | | | |
|---|---|---|---|---|
| ID | Pb | Cr | Cd | As |
| MG | 0.061 | 3.70 E-05 | 5.95 E-04 | 0.019 |
| MF | 0.075 | 4.34 E-05 | 2.38 E-03 | 0.011 |
| ML | 0.075 | 5.77 E-05 | 5.10 E-03 | 0.010 |
| MK | 0.045 | 4.87 E-05 | 5.10 E-03 | 0.010 |
| MA | 0.103 | 3.66 E-05 | 5.95 E-04 | 0.071 |
| MLE | 0.062 | 6.95 E-05 | 7.65 E-04 | 5.38 E-03 |
| WA | 0.100 | 2.79 E-05 | 3.14 E-03 | 5.95 E-03 |
| ST | 0.111 | 8.53 E-05 | 3.14 E-03 | 0.011 |
| AK | 0.073 | 4.77 E-05 | 1.27 E-03 | 9.06 E-03 |
| BK | 0.075 | 4.90 E-05 | 5.35 E-03 | 9.63 E-03 |
| PA | 0.080 | 3.37 E-05 | 1.19 E-03 | 0.014 |
| GU | 0.243 | 4.12 E-05 | 2.21 E-03 | 0.016 |
| PI | 0.078 | 7.49 E-05 | 4.25 E-04 | 0.012 |
| BA | 0.276 | 7.49 E-05 | 6.80 E-04 | 0.012 |
| JA | 0.057 | 3.37 E-05 | 3.48 E-03 | 7.93 E-03 |
| SA | 0.067 | 3.61 E-05 | 1.70 E-03 | 9.92 E-03 |
| WM | 0.056 | 2.86 E-05 | 7.65 E-04 | 6.80 E-03 |
| WAP | 0.137 | 4.53 E-05 | 3.65 E-03 | 9.07 E-03 |
| KA | 1.076 | 3.52 E-05 | 1.10 E-03 | 0.010 |
| PO | 0.066 | 2.50 E-05 | 1.87 E-03 | 0.010 |
| CA | 0.074 | 3.79 E-05 | 2.21 E-03 | 0.010 |
| CO | 1.073 | 4.95 E-05 | 5.95 E-04 | 8.50 E-03 |
| MU | 0.124 | 4.68 E-05 | 2.46 E-03 | 9.58 E-03 |

The obtained results on health risk index for all foodstuffs samples are summarized in Table-3. The Table shows that the HRI in fruit samples varied Pb (0.045 – 1.076), Cr (2.50 E-03 – 8.53 E-03), Cd (4.25 E-04 – 5.35 E-03) and As (5.38 E-03 – 0.071). The health risk assessment associated with heavy metals (Pb, Cr, Cd and As) of fruit locally grown, estimated exposure and risk index were calculated. The result showed in Table-3. The result

revealed that health risk index for Pb, Cr, Cd and As for all type of fruits are lower than 1 indicating safe for the consumer. Generally, HRI < 1 means that the exposed population is safe of metals health risk while HRI > 1 means the reverse (Khan *et al.,* 2008). It is obvious that, the population is therefore at no risk of Pb, Cr, Cd and As.

## 7. Conclusions

The concentration trend of toxic metals in selected fruits follows the order of Pb > Cr > As > Cd. It observed that, lead content in the studied fruit samples were ranged from 1.867 - 44.337 mg/kg. Among the analyzed fruits guava, banana, indian olive and karanda showed a very high level of lead i.e. 10.046, 11.391, 42.713 and 44.337 mg/kg respectively, which exceeded the permissible limit of Pb. It is to be noted that guava, banana, indian olive and karanda show exceptionally higher Pb concentrations. Chromium was found in almost all selected fruit varieties here, strawberry showed the highest chromium content (1.506 mg/kg) followed by mango lokhna (1.019 mg/kg), mango lengra (1.277 mg/kg), banana (sagor) (1.070 mg/kg), pineapple (1.323 mg/kg), which exceeded the recommended limit of Cr, and the lowest chromium content pomegranate (0.442 mg/kg), wax apple (0.493 mg/kg). It showed that the concentration of cadmium in fruit samples varied from 0.002 - 0.063 mg/kg. The results showed that the concentration of total cadmium in collected fruit samples were within the normal limit**.** The concentrations of arsenic in fruit samples were ranged from 0.019 - 0.252 mg/kg. The present results show that the concentration of total arsenic in collected fruit samples were within the normal limit**.** From the analysis samples will pose no risk as they remain below than the recommended limit for these elements except eight fruits samples (guava, banana, indian olive, karanda, mango lokhna, mango lengra, strawberry, pine-apple) in terms of lead and chromium. From the result of health risk index, it is obvious that the population is therefore at no risk of Pb, Cr, Cd and As.

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