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# Investigation of Irrigation Water Quality & Soil Fertility Condition Around Bhadra River at Khulna

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## ABSTRACT

This paper is an attempt to analyze the water quality of Bhadra River in Khulna district for irrigation purpose. The farmers residing in the western fringe of Khulna city in Bangladesh, use the sewage-fed water of the Bhadrariver for irrigation as good quality surface water is not available as well as higher cost in groundwater irrigation. The present study was undertaken to evaluate the suitability of this river water for irrigation during the wet season since this period is more sensitive to crop agriculture in the study area. A total of five water samples from five different stations, were collected and analyzed for pH, EC, TDS, major cations ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$) and anions ($Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$). Chemical data were used for calculation of SAR for better understanding the suitability of river water for irrigation use. In wet season the observed average value for water pH 6.94; EC 1726 (µs/cm); TDS 1300(mg/l); $Na^+$245 (mg/l), $CI^-$374 (mg/l); $Ca^{2+}$45.93 (mg/l); $Mg^{2+}$23.60 (mg/l); $SO_4^{2-}$4.2 (mg/l), $NO_3^-$0.52 (mg/l); SAR 41.55. The results revealed that river water was found to be safe for irrigation with regards to EC and TDS but SAR indexexceeded the allowable limits. Nevertheless, $Na^+$cation and $Cl^-$anion exceeded the acceptable limits for irrigation. Soil salinity intrusion is also an increasing problem in the coastal areas of Bangladesh. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. Laboratory analyses for soil samplesobtained an average value of pH (8.52), P (11.42 µg/g), Zn (1.33µg/g), Cu (3.16 µg/g), K (0.22 meq/100g), Ca (26.60 meq/100g), Mg (5.90 meq/100g) and N (0.103 %). Comparedto standard values it was found that Zn and Kwere within the range of standard value. However, the nutrients of soil such as P, Ca, Mg and Cu exceeded the acceptable limit for soil fertility.

***Keywords:*** *Irrigation, Salinity, Suitability, River water, SAR.*

## 1. INTRODUCTION

Water is the most common substance on earth. It covers more than 70 percent of earth's surface. It fills the ocean, rivers and lakes and is the ground and in the air we breathe. Water is everywhere. Regardless of language or culture, all living beings share this basic need for their survival. Water plays an important role in the world economy. Approximately 70% of the freshwater used by humans goes to agriculture. Fishing in salt and fresh water bodies is a major source of food for many parts of the world. Much of long distance trade of commodities (such as oil and natural gas) and manufactured products is transported by boats through seas, rivers, lakes and canals. Large quantities of water, ice, and stream are used for cooling and heating, in industry and homes. Water water excellent solvent for a wide variety of chemical substances, as such it is widely used in industrial processes, and cooking and washing. The most important use of water in agriculture is for irrigation, which is a key component to produce enough food. Irrigation takes up to 90 % of water withdrawn in some developing countries and significant proportions in more economically developed countries (In the United states, 30% of fresh water usage is for irrigation).

Bangladesh is an irrigated agriculture based country and is dependent on adequate water supply of usable quality. As the crop yield is directly related to the quality of water used for irrigation, an assessment of groundwater suitability for irrigation is essential for the growth of food production and poverty eradication. Coastal Bangladesh, covering about 3.22 million ha, of which 2.00 million ha are cultivated land (SRDI, 2001), used to have great potential for agricultural development, but increasing salinity, mainly in the soil's root zone, is the largest limitation factor (Rahman *et al.*, 1993). Previously, water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available (Islam and Shamsad, 2009). However, salinity increase have been one of the major problems for traditional agricultural practices in coastal Bangladesh for several decades (Rahman *el al.*, 2011).

Salinity is a global problem. The continuous loss of arable land due to irrigation in arid and semi-arid regions of the world, over exploitation and mismanagement contribute to global change in a way which currently appears to draw much less concern in the media and the general public than the accumulation of greenhouse gases: Carbon dioxide, methane and others, in our atmosphere and putative temperature increase and climate changes associated with them. Nevertheless, the advancement of desertification by salinization and its threatening of global agriculture can be readily quantified (Smedema & Shiati, 2002).

Dumuria upazilla, in Khulna district is in the south west coastal region of Bangladesh where saline water intrusion is the most severe where farmers mostly cultivated a single rice crop in the wet season under rainfall conditions. The use of groundwater as sole source of irrigation remains a risky venture, owing to the possible intrusion of saline water from the river into the coastal aquifers if the water level of aquifers is lowered because of excessive withdrawal of water for irrigation. However, even in monsoon season, there are times when pro longed drought condition persists and farmer are at stake in choosing which source of water to use as irrigation water. Therefore, a detailed investigation regarding the irrigation water quality and their salinity hazard classification has to be done for the monsoon season in the area, particularly for the available water resources including surface water and shallow groundwater. As most of people of these districts are dependent on agriculture and fisheries, keeping these mind, the objectives of the research were to assess the hydrochemistry of surface water and groundwater of the area in the monsoon season, to evaluate the suitability of irrigation water quality of different sources of Dumuria upazilla of Khulna district in Bangladesh.

## 2. METHODOLOGY

### 2.1Sampling, Preservation, and Preparation of Water Sample

Prior selecting the water sampling sites from a well-studied reconnaissance survey, samples were collected from 5 sampling stations based on the characterizing features of the locations along the river. Samples were collected from the midstream of the river by using an engine boat and following the guidelines of standard methods. Samples for cationic and anionic analyses were collected in separate 500 ml PET bottles. Then samples were carried to the laboratory and tested immediately.

| Location | Longitude | Latitude |
|---|---|---|
| Site 1 | $89^0$24’54.09” | 22°47’37.4” |
| Site 2 | $89^0$25’4.53” | 22°47’47.8” |
| Site 3 | $89^0$25’19.05” | 22°48’.3.5” |
| Site 4 | $89^0$25’34.2” | 22°48’27.4” |
| Site 5 | $89^0$24’48.4” | 22°48’52.3” |


Figure-1: Location of study area.

### 2.2 Laboratory Measurements

Na, K, Ca, Mg, $NO_4$, $SO_4$, $PO_4$ were analyzed following the standard procedures. Titrimetric methods were used for determining Ca, Mg and Cl ions. K was measured by direct use of flame photometer, $NO_3^-$, $SO_4^{2-}$ and $PO_4^{3-}$ were measured by using spectrophotometer. TDS was measured by keeping the water sample in oven for 24 hours at 105°C. Physical properties of water DO, pH, EC were measured by DO meter, pH meter and Conductivity meter, respectively.

### 2.3 Data Analysis for Water Sample

Different water quality parameters like EC, TDS classes were used in the study to assess the quality of the water. In agriculture, water quality is an important criterion for the development of a successful and sustainable irrigation Scheme. In order to assess the suitability of the river water for irrigation use, various parameters like EC, SAR index were measured to assess the suitability of water for using in irrigation. Besides, every water quality parameter was compared to their respective standard value to assess their suitability for irrigation.

### 2.4 SAR Index Determination

The Sodium adsorption ratio (SAR) is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural Irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is also a standard diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil.
The formula for calculating the sodium adsorption ratio (SAR) is:

$$SAR = \frac{Na}{\sqrt{0.5(\mathrm{Ca} + \mathrm{Mg})}}$$

Where Na, Ca, Mg are in mg/1.

### 2.5 Sampling, Preservation and Preparation of Soil Sample

Total 2 soil samples were collected at 0-15 cm depth from three different locations of Bhadra river basin at Dumuria in Khulna district. Samples were collected with plastic packets. After collecting, the soil samples were air-dried and then a composite sample was prepared by mixing unit samples. Then samples were used for chemical analysis.

### 2.6 Experimental Methodology

The soil pH was measured by pH meter. K (potassium) was measured by flame photometer. Ca, Mg, Cu, Zn and P were measured by soil extraction method. Then the soil parameters were compared with their respective standard value to assess soil quality.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Water Quality of Bhadra River Water

Bhadra River is coastal river. Due to the unequal precipitation and mixing of sea water, the river water quality varies throughout the year. Here in the wet season, water quality parameters were analysed.

Table 3-1: Tested Results of Bhadra River Water Quality Parameters at Wet-Season

| Sample No. | pH | Ec (µs/cm) | TDS (mg/L) | DO (mg/L) | $Na^+$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Cl^-$ (mg/L) | $NO_3^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $PO_4^{3-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.89 | 1875 | 1320 | 7.6 | 202 | 44.38 | 21.50 | 308 | 0.60 | 3.0 | 0.71 |
| 2 | 6.88 | 2400 | 1530 | 5.6 | 223 | 44.98 | 21.90 | 340 | 0.40 | 4.0 | 1.05 |
| 3 | 6.95 | 1729 | 1210 | 7.2 | 307 | 47.91 | 23.60 | 468 | 0.51 | 6.4 | 0.92 |
| 4 | 7.02 | 1627 | 1200 | 6.9 | 260 | 44.39 | 25.20 | 396 | 0.65 | 3.5 | 0.74 |
| 5 | 6.98 | 1672 | 1240 | 7.3 | 234 | 47.99 | 25.70 | 356 | 0.43 | 3.9 | 1.03 |

In wet season the observed average value for water pH 6.94; EC 1726 (µs/cm); TDS 1300(mg/l); $Na^+$245 (mg/l), $CI^-$374 (mg/l); $Ca^{2+}$45.93 (mg/l); $Mg^{2+}$23.60 (mg/l); $SO_4^{2-}$4.2 (mg/l), $NO_3^-$0.52 (mg/l); SAR 41.55.

#### 3.1.1 Suitability of Bhadra River Water for Irrigation

On irrigated agricultural lands, salinization is one of bountiful inauspicious environmental and human induced impacts that persuade loss of production in gigantic scale. Salinization critically limits the choice of crops, deleteriously affect crop germination and yields and can provoke soils to be inappropriate to work. It is important that all appraisals regarding irrigation water quality tobe linked with the evaluation of soils to be irrigated. The suitability of river water samples for irrigation use is governed by the mineral constituent present in the water. The major physico-chemical parameters, which determine the suitability of river water for irrigation, are pH, EC, TDS, chloride, sulfate, nitrate, sodium, potassium, calcium, magnesium etc. In assessing the suitability or waters for irrigation use, water quality characteristics that affect agricultural production need to be evaluated. Irrigational suitability of the Bhadra River and its connected channel was evaluated by determining the concentration of various water quality parameters (pH, EC, TDS, chloride, sulfate, nitrate, sodium, potassium, calcium, magnesium, etc.) and SAR index.

Table 3-2: Quality evaluation of irrigation water with respect to BIWOS Standard

| Parameter | Rate of Hazards | Water class |
|---|---|---|
| pH | 5.1-6.4 | No problem |
| | 6.5-8.5 | Moderate |
| | 8.5-9.5 | Sever |
| EC | <250 | Excellent |
| | 250-750 | Good |
| | 750-2000 | Permissible |
| | 2000-3000 | Doubtful |
| | >3000 | Unsuitable |
| TDS (mg/l) | <450 | Good |
| | 450-2000 | Permissible |
| | >2000 | Unsuitable |
| $Cl^-$(mg/l) | <80 | No problem |
| | 80-200 | Moderate |
| | >200 | Sever |
| $Na^+$ (mg/l) | <60 | No problem |
| | 60-180 | Moderate |
| | >180 | Sever |
| $NO_3^-$ (mg/l) | <5 | No problem |
| | 5-30 | Moderate |
| | >30 | Sever |
| SAR | 10-18 | Good |
| | 18-26 | Doubtful |
| | >26 | Unsuitable |

### 3.1.2 Physico-Chemical Characteristics of Bhadra River Water

The obtained pH value of water was found 6.94 which is close to 7 indicates that the water is suitable for irrigation purpose. Salinity of river water that is used for irrigation is determined by EC, which is used as a surrogate measure or TDS concentration in water. According to the classifications of irrigation water based on EC and TDS, the river water was within the permissible limit. Comparing with BIWQS (DoE, 1997), the value of EC in river water is not exceeded the tolerance limit (2250 us/cm) for irrigation. Continuous use of irrigation water containing higher EC leads to formation of saline soil. The higher the EC, less quantity of water is available to plants, even though the soil appears to have plenty of moisture. The main effects of salinity on plants can include reduction in growth rate, damage of meristems in growing shoots, reductions in yield components of rice, or typical symptoms of nutritional disorders under osmotic and ionic stress. Therefore, successful use of this river water requires salt tolerant plants, good soil drainage, excess irrigation for leaching, and/or periodic utilization of low salinity water. The chloride contents of the Bhadra River exceeded the tolerance limit (200 mg/l) for irrigation in Bangladesh (DoE, 1997). As per the chloride classification of irrigation water, the river water come under the severe category which indicates that water was not free from chloride hazard. Generally, chloride is not adsorbed or held back by soils, therefore it moves readily with the soil-water, is taken up by the crop, moves in the transpiration stream, and accumulates in the leaves. If the chloride concentration in the leaves exceeds the tolerance of the crop, injury symptoms develop such as leaf burn or drying of leaf tissue. The sulfate concentration in the Bhadra River water was recorded to be very high and it was in the good to injurious category. The tendency of high sulfate concentrations is to limit the uptake of calcium by plants. This decrease in the uptake of calcium is associated with the other hand, with relative increases in the absorption of sodium and potassium. Nitrate is one of the primary macronutrients that stimulate plant growth. Inherent soil nitrogen or supplementary fertilizers are the common sources, but nitrate in the irrigation water has much the same effect as soil-applied fertilizer nitrogen and an excess will cause problems, just as too much fertilizer would.

### 3.1.3 SAR Index of Bhadra River Water

The degree to which the irrigation water tends to enter into cation exchange reaction in soil can indicated by the sodium adsorption ratio. Excess sodium gets adsorbed on soil particles, thus changes the soil properties and also reduces permeability. In this study, SAR 41.55 was found to exceed the tolerable range SAR 26 and thus causes big problem for irrigation.

### 3.2 Soil Quality of Bhadra River Catchment

Table 3-3: Nutrients level chart of soil (SRDI) Standard

| Nutrients | Very low | low | Medium | Optimum | High | Very High |
|---|---|---|---|---|---|---|
| P(µg/g) | <7.5 | 7.51-15 | 15.1-22.5 | 22.5-30 | 30.1-37.5 | >37.5 |
| Zn(µg/g) | <0.45 | 0.45-9 | 0.91-1.35 | 1.35-1.81 | 1.81-2.25 | >2.25 |
| Cu(µg/g) | <0.15 | 0.15-0.3 | 0.31-0.45 | 0.45-0.6 | 0.61-0.75 | >0.75 |
| K(meq/100g) | <0.09 | 0.091-18 | 0.181-0.27 | 0.271-.36 | 0.361-45 | >0.45 |
| Ca(meq/100g) | <1.5 | 1.5-3.0 | 3.1-4.5 | 4.51-6 | 6.1-7.5 | >7.5 |
| Mg(meq/100) | <0.375 | 0.375-0.75 | 0.751-1.1 | 1.2-1.5 | 1.5-1.875 | >1.87 |

Table 3-4: Nutrients level in Collected Field Soil Samples Near Bhadra River

| Sample No | pH | N (%) | Zn (µg/g) | Cu (µg/g) | K (meq/100g) | Ca (meq/100g) | P (µg/g) | Mg (meq/100) |
|---|---|---|---|---|---|---|---|---|
| 1 | | 0.095 | 1.64 | 3.32 | 0.21 | 26.55 | 13.63 | 5.83 |
| 2 | | 0.111 | 1.02 | 3.00 | 0.22 | 26.65 | 9.20 | 5.97 |
| Avg. | | 0.103 | 1.33 | 3.16 | 0.22 | 26.60 | 11.42 | 5.90 |

### 3.2.1 Soil Fertility Based on Available Nutrients

The optimal pH range for agricultural soil in most plants is between 6.5 and 8.5. Because pH levels control many chemical processes that take place in the soil specifically, plant nutrient availability it is vital to maintain proper levels for plants to reach their full yield potential. The average obtained pH value is 8.52 which suggest alkaline soil. Zinc is essential plant micronutrient. It is important for production of growth hormones. Good root development depends on Zn. So, maintaining adequate Zn content is very necessary. The average obtained value of Zn is 1.31 which indicates that the Zn content is medium and needs to increase. Copper is essential elements in plants growth. Without adequate copper contents plants fail to grow properly. So, maintaining fair amount of copper is very essential. The average obtained value of copper is 3.16 (µg/g) which indicates a higher amount of copper present in soil. Potassium (K) is an essential nutrient for plant growth and is classified as a macronutrient due to large quantities of K being taken up by plants during their life cycle. But when the supply from the soil is not adequate, K must be supplied in a fertilizer program. The average obtained value of K is 0.22 (meq/100g) which indicates a moderate amount of K present in soil. Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. Phosphorus is one of the three nutrients generally added to soil as fertilizer. One of the main roles of P in living organisms is in the transfer of energy. Organic compounds that contain P are used to transfer energy from one reaction to drive another reaction within cells. Adequate P availability for plants stimulates early plant growth and has tens maturity. The average obtained value of P is 11.42 which indicates low amount of P present in soil. So, quantity of P needs to increase. Calcium is essential for many plant functions. It is needed for plants for cell division, Cell wall development, nitrate uptake and metabolism, enzyme activity, etc. The average obtained value of $Ca^{2+}$ is 26.60 (meg/100g) which indicates very high amount of $Ca^{2+}$ present in soil. Magnesium is an essential plant nutrient. It has a wide range of key roles in many plant functions, one of the magnesium's well-known roles is in the photosynthesis process, as it is a building block of the Chlorophyll, which makes leaves appear green. The average obtained value of Mg is 5.90 (meg/100g) which indicates a very high amount of Mg present in soil.

## 4. CONCLUSIONS

The first objective of this study was to determine the water quality of the Bhadra River and its suitability for irrigational use as the river is a major source of water for agricultural activities due to traditional practice with surface water irrigation as well as higher cost in ground water irrigation. For this study, total five river water samples were collected during wet season. Test results indicated that the Bhadra river water is suitable for irrigational uses. pH of water samples were observed to be in the normal range (6.5-8.4) irrespective of sampling months and stations, indicating that the river water was suitable for irrigation.EC, TDS, major cations ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$) and anions ($Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$), values are in tolerate limit, but SAR Index restricted the Bhadra River water for use in irrigation. The second objective of this study was to identify the soil quality and soil fertilization status of Bhadra river catchment. From the analysis of Bhadra river catchment soil data, it was found that in collected soil samples only K and Zn were within the range of standard value. But, the nutrients of soil such as P, Ca, Mg and Cu were beyond the suitable ranges.

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