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# Impact of Wastewater and Soil of Fertilizer Production Plant on the Water of the Meghna River

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**Abstract**
Wastewater and soil from Ashuganj Fertilizer and Chemical Company Limited (AFCCL) were characterized to assess the extent of pollution in the water of the Meghna river. Wastewater, soil and river water samples were collected from inside and around the factory and analyzed for temperature, pH, DO, EC, TDS, TSS, ammonia, phosphate, iron and copper. The results show that the wastewater contains higher concentration of ammonia, pH and EC than standard limit of DoE while other parameters exist near or within the standard limit. High concentration of ammonia is also observed in the soils of inside the factory due to the leakage of ammonia or urea during production and also transportation of raw materials and fertilizer. This high level of ammonia in the waste water and soil deteriorated the quality of river water of the Meghna. It is found that the river water is heavily polluted with ammonia which may cause toxicity to fish and other aquatic organisms as well as human health. Hence, in terms of quality, the river water of the Meghna is vulnerable to pollution from untreated waste water and runoff from ammonia or urea fertilizer leakage in and around the operation of river parts. It is therefore recommended that the disposal of improperly treated or untreated wastewater should be stopped and repaired the leakage of the fertilizer production plant to save the Meghna river water from severe pollution.

**Keywords:** AFCCL, ammonia, untreated wastewater, pollution, toxicity to fish.

## Introduction

Now a days environmental pollution is a great matter of concern. This is considered as a global problem because of its adverse effects on human health, plants and animals. Most of the industries discharge their wastes directly to the river, canal or sea without any treatment.

This is one of the major causes of water pollution in Bangladesh. Water is the most vital element among the natural resources and is crucial for the survival of all living organisms including human, food, production and economic development. Moreover, in Bangladesh, the environment, economic growth and developments are all highly influenced by water because of its regional and seasonal availability and the quality of surface and ground water.

In Bangladesh, the main reason of water pollution is also industrial wastewaters. Environmental pollution by industrial wastes is not a problem in the developed countries but also it is a big problem in developing countries like Bangladesh. Main sources of pollution in Bangladesh are

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industries like textiles, tanneries, fertilizer industries, steel mills, sugar industries etc (Sultana *et al* 2009, Islam *et al.* 2010, DoE, 2001). These industries use huge amounts of chemicals; as a result effluents from these industries contain different types of toxic chemicals. Pollutants can kill animals and plants, imbalance ecosystems, degrade air quality radically, damage buildings, and generally degrade quality of life. Factory workers in areas with uncontrolled industrial pollution are especially vulnerable (Rahman *et al.* 2010, Smith 2010). A recent survey conducted by the DoE (Department of Environment) notes that more than 1200 industries of the country discharge about 35,000 cubic meter wastes that pollute air, water and land ultimately leading to environmental degradation (Hossain 2007). In Bangladesh, industrial units are mostly located along the banks of the rivers. There are obvious reasons for this such as provision of transportation for incoming raw materials and outgoing finished products. Unfortunately as a consequence, industrial units discharge effluents directly into the rivers without any consideration of the environmental degradation and water has been polluted continuously as a result of addition of large amount of toxic materials (Terry 1996, Bangladesh: State of Environment, 2001).

As Bangladesh is an agro-based industrially developing country, fertilizer factories has a big contribution in the development of agricultural sector. Production process of fertilizer is very complex and large amounts of chemical are used in different steps of the production of fertilizer. Effluents from the factories also contain different types of chemicals. If proper controlling measures are not taken, these effluents can have harmful contribution for the environment. Air pollution and noise pollution also occur from these industries. The chief gaseous pollutants from a urea fertilizer plant are CO, $CO_2$, $NO_x$, $SO_x$, urea dust, ammonia gas etc. As like other countries in the world, pollution by fertilizer industrial waste is also a problem in Bangladesh (Sultana$_a$ *et al.* 2011a, Islam et al. 2010, Alam and Hossain 2009, Saleque 2009, Tayob *et al.* 2007, DoE 1993, 2001). There are six fertilizer factories in Bangladesh under the Bangladesh Chemical Industries Corporation (BCIC). Ashuganj Fertilizer and Chemical Company Limited (AFCCL) is one of them. This factory is located at the bank of the Meghna River and wastewater from the factory are discharged into the river. The purposes of the study are to characterize the wastewater and soil inside the factory and investigate how much these contribute to pollute the water of the Meghna River.

## Materials and Methods

*Location of the study area*

Ashuganj Fertilizer and Chemical Company Limited (AFCCL) is situated on the east bank of the river Meghna about 2 km south of Aahuganj railway station in the district of Brahmanbaria, Bangladesh approximately 100 km north of Dhaka (Fig.1).

*Company Background*

AFCCL was established by the Ministry of Industries (MOI) of Government of Bangladesh (GOB). For establishment of the factory the main contractor was Foster Wheeler Limited, UK and commissioned on 15$^{th}$ December, 1981. Later on the 1$^{st}$ December, 1983 the factory was handed over to Bangladesh Chemical Industries Corporation (BCIC). Since then AFCCL has been operated as an enterprise of BCIC. Mainly urea is produced in this factory.

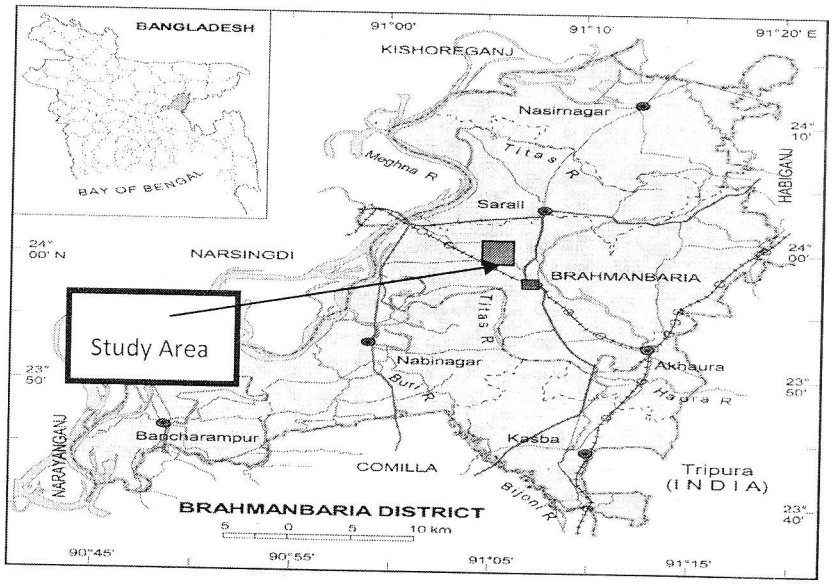


**Figure 1:** The location of the study area.

*Sample Collection*

Eight wastewater samples were collected from different locations of inside the factory and wastewater drains whereas four river water samples were collected from discharge point of wastewater to the downstream of the river. Seven soil samples (0-15 cm) were collected randomly in the vicinity of the surface-water sampling locations inside and around the factory. Collection and analysis of the samples were performed in rainy Seasons in June to October, 2010 by proper sampling procedure. The locations of the sampling sites with ID numbers are shown in Table -la & 1b.

*Sample Analysis*

The physicochemical parameters, anion concentrations and trace element concentrations of wastewater, river water and soil samples were analyzed by different standard methods in the laboratory of analytical research division, Instrumentation and Calibration Section Laboratory (ICSL), BCSIR , Dhaka and Department of environmental Sciences Jahangirnagar University, Savar, Dhaka. Physicochemical parameters such as temperature, pH, total suspended solid (TSS), total dissolved solid (TDS), electrical conductivity (EC), dissolved oxygen (DO) of the wastewater and river water samples were measured using various standard methods (APHA 1991). The soil samples were air dried, sieved (1mm) and after oven dried at 80 °C, ground to powder. After acid digestion, the residue was dissolved in dilute acid solution to yield the sample solutions. The pH of the soil samples were determined by using a soil pH meter (Soil pH Meter, TAKEMURA Electric works LTD). A quantitative analysis of ammonia ($NH_3$) and phosphorus (P) of the waste water, river water and soil were determined by UV Spectrophotometer (Model: UV-1650 PC; SHIMADZU) at 420 and 400 nm wave length respectively. Two types of reagents such as EDTA and Nesslare reagents were used for ammonia determination. Calibration curve

was prepared by using four ammonia standard solutions. Then blank and prepared samples were run into the UV spectrophotometer for determination of ammonia concentration. Phosphate ($PO_4^{3-}$) concentration of the samples were determined from phosphorus (P) concentration using the factor (95/31=3.0645). Further a quantitative analysis of trace elements such as iron (Fe) and copper (Cu) of the wastewater, river water and soil were determined by Atomic Absorption Flame Emission Spectrophotometer (AAS) (Model: A 306647; SHIMADZU CORP 00440).

Table 1a: Locations of the sampling sites of Wastewater and river water of the Meghna with ID numbers

| Water | Serial No. | Sample ID | Sampling Site |
|---|---|---|---|
| Wastewater | 01 | W.W-1 | $NH_3$ cooling tower |
| | 02 | W.W-2 | Urea cooling tower |
| | 03 | W.W-3 | Surface drain $NH_3$ |
| | 04 | W.W-4 | $NH_3$ plant (2) |
| | 05 | W.W-5 | Surface drain urea |
| | 06 | W.W-6 | Urea surface drain (2) |
| | 07 | W.W-7 | Common surface drain |
| | 08 | W.W-8 | Effluent treatment drain |
| River water | 01 | R.W-1 | Discharge point into river |
| | 02 | R.W-2 | 100m from discharge point |
| | 03 | R.W-3 | Downstream |
| | 04 | R.W-4 | Downstream |

Table 1b: Locations of the sampling sites of soil of AFCCL with ID numbers

| Serial No. | Sample ID | Sampling Site |
|---|---|---|
| 01 | S-1 | Near $NH_3$ storage tank |
| 02 | S-2 | Near laboratory |
| 03 | S-3 | Water treatment area |
| 04 | S-4 | Urea plant |
| 05 | S-5 | Godown Area |
| 06 | S-6 | Discharge point of waste water |
| 07 | S-7 | Vicinity of the Meghna River |

## Results and Discussion

Characterizations of Wastewater

*Concentrations of the physicochemical properties of the wastewater*

The physicochemical properties of the wastewater of the fertilizer factory varied with the sampling locations which is shown in Fig.2. The temperature of the waste water from the AFCCL was varied from 38.4 to 33.6°C with average value 35.93°C. Water pH influences the activity of other properties of water body, activity of organisms and potency of toxic substances present in the aquatic environment (Rouse 1979). In the wastewater the range of the pH values varied from 8 to 10.2 with average value 8.82. That means most of the sample water from the industry is alkaline in nature. Higher pH is due to the presence of higher concentration of ammonia. DO is very important for the aquatic fish and other organism. In this study, DO value

of water samples ranges from 5.07 to 7.24 with average value 6.07. Electrical conductivity is widely used to indicate the total ionized constituents of water. In the collected samples the highest electrical conductivity was varied from 3290 $\mu$s/cm to 550 $\mu$s/cm with average values 1432.5 $\mu$s/cm. Total Dissolved Solids (TDS) is an expression for the combined content of all inorganic and organic substances contained in a liquid which are present in a molecular, ionized or micro-granular and suspended form. High TDS value in the effluent increases density of water, reduces solubility of gases (like Oxygen) and utility of water for drinking, irrigation and industrial purposes. In the collected water samples the range of TDS was found 1380 to 210 mg/L and the average value was found 622.75 mg/L. During this study the highest TSS was found 5.312 mg/L and the lowest TSS was found 0.148 mg/L with mean value 1.02mg/L.

*Concentrations of the anionic properties of the wastewater*

The anionic properties of the waste water of the fertilizer factory were also varied with the sampling locations which are shown in Fig.2. Ammonia is one of the most important water quality parameter for the waste water that is discharged from the fertilizer factory. As AFCCL is a urea fertilizer producing factory it discharges large amount of ammonia. Ammonia is rich in nitrogen so it makes an excellent fertilizer. In fact, ammonium salts are a major source of nitrogen for fertilizers. However, like nitrates, excess ammonia may speed the process of eutrophication in waterbodys. Also, ammonia is much more toxic to fish and aquatic life when water contains very little dissolved oxygen and carbon dioxide (Knepp and Arkin 1973). Ammonia concentration of wastewater samples from the fertilizer factory varied from 20.16mg/L to 418.32 mg/L with average value of 163.18 mg/L. The element phosphorus is necessary for plant and animal growth. But, if too much phosphate is present, algae and water weeds grow wildly, choke the waterway, and use up large amounts of oxygen. Many fish and aquatic organisms may die. In the wastewater samples that were analyzed during the study, highest phosphate concentration was measured 3.708 mg/L lowest concentration was measured 0.367 mg/L with average value 1.794mg/L.

*Concentrations of the trace elements in the wastewater*

Iron is the second most abundant metallic element in the Earth's outer crust. This is an essential element in the metabolism of animals and plants. Naturally small amount of iron is present in ground water and surface water. In this study, the highest concentration of iron in wastewater was measured 0.5362 mg/L and lowest concentration was measured 0.0287 mg/L with the average value of 0.294 mg/L. Copper is an important trace element. Among the water samples highest concentration of copper was found 0.0338 mg/L and lowest concentration was 0.0037 mg/L with average value 0.018 mg/L.

*Characterization of the soil of fertilizer industry*

In the soil samples of the fertilizer factory, pH, ammonia and phosphate were varied slightly with the sampling locations (Fig.3). The average pH of soil was observed 7.1. Among the soil samples highest concentration of ammonia was measured 116.693 mg/L and lowest concentration that was observed 75.65 mg/L with average value 93.7 mg/L. It may be noted that ammonia concentration in soil samples that were collected from inside the factory was comparatively higher than

downstream area as it is far away from the factory. This high concentration may occur due to leakage of ammonia or urea during production and transportation of raw materials and fertilizer. Soil samples that were also collected from inside and around the factory represent much higher concentrations of phosphates than the wastewater samples. The range of phosphate concentration was found 68.093 to 34.445 mg/L with the average value 56.15 mg/L.

Iron is an essential trace element of soil and concentration of iron in the soil samples of the AFCCL is high. Among soil samples highest concentration was observed 28512.5 ppm and lowest concentration was observed 14603 ppm with average value 20743.6 ppm. Concentration of copper in the soil samples ranged from 7.86 ppm to 163.94 ppm with average concentration 38.57 ppm. Similar types of results were observed in the soils of industrial area of Gazipur (Sultana *et al.*, 2011b). However, Copper concentration was comparatively lower in soil samples that were taken from inside the factory. But samples that were taken from the river side contain higher concentration of copper. Wastewater from the factory may not responsible for this high concentration.

Characterization of the water of the Meghna River

*Concentrations of the physicochemical properties of the river water*

The water samples of the Meghna River were collected from the discharge point of wastewater to the downstream of river. It is found that although the physicochemical properties such as temperature, pH, DO and TSS remain steady throughout the samples but EC and TDS varied with the sampling sites (Fig.4). Average values of temperature, pH, DO and TSS of the samples were found 29.4 °C, 7.8, 6.2 mg/L and 0.72 mg/L, respectively.

Electrical conductivity is widely used to indicate the total ionized constituents of water. In the collected samples the range of electrical conductivity was found 160 to 80 $\mu$s/cm with average value 107.5 $\mu$s/cm. The TDS value of river water varied from 160 to 105 mg/L with average value 126.25 mg/L.

*Concentrations of the anionic properties of the river water*

AFCCL is a urea fertilizer producing factory it discharges large amount of ammonia. Further when it rains, varying amounts of ammonia wash from the soils into the river. Ammonia is toxic to fish and aquatic organisms, even in very low concentrations. Ammonia levels greater than approximately 0.1 mg/L usually indicate polluted waters (Knepp and Arkin,1973). In the river water samples that were analyzed during the study, highest ammonia concentration was observed in the discharge point of wastewater into the river and then gradually it becomes constant up to downstream (Fig.4). The range of ammonia concentration of river water was observed 51.18 mg/L to 184.45 mg/L with average value of 85.43 mg/L. The range of phosphate concentration was observed 2.91 mg/L to 0.37 mg/L with average value 1.91mg/L.

*Concentrations of the trace elements in the river water*

In this study, the highest concentration of iron in river water was measured 0.28 mg/L and lowest concentration was measured 0.21 mg/L with the average value of 0.21 mg/L. No cupper was

detected in the studied river water. So it is found that the water samples do not contain harmful copper.

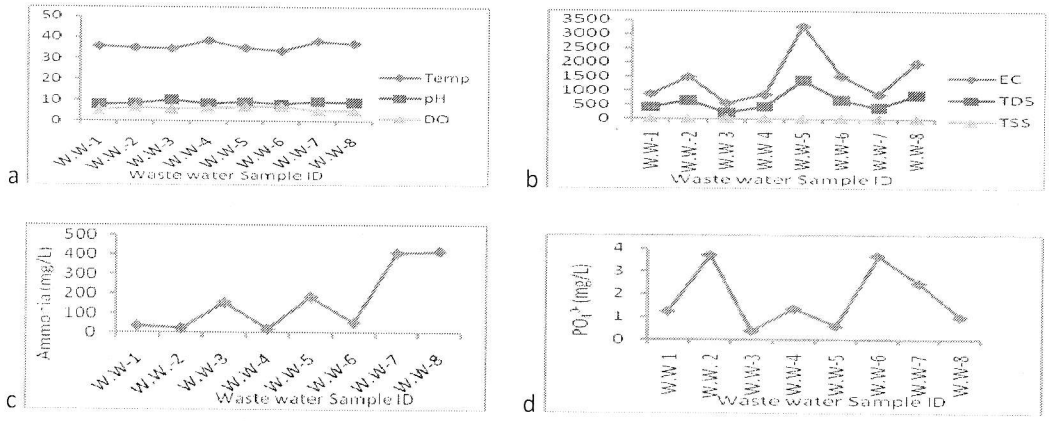


**Figure 2:** The variation of physicochemical properties of wastewater with sampling sites. a-Temp, pH, DO, b- EC, TDS, TSS, c-$NH_3$, d- $PO_4^{3-}$.

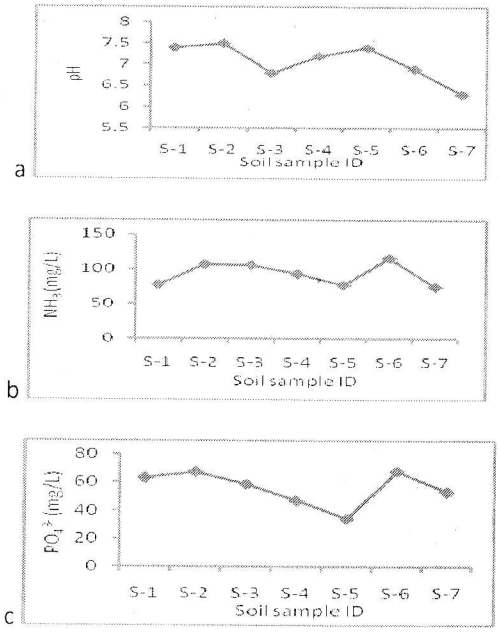


**Figure 3:** The variation of chemical properties (a-pH, b-$NH_3$, c-$PO_4^{3-}$)of soil.

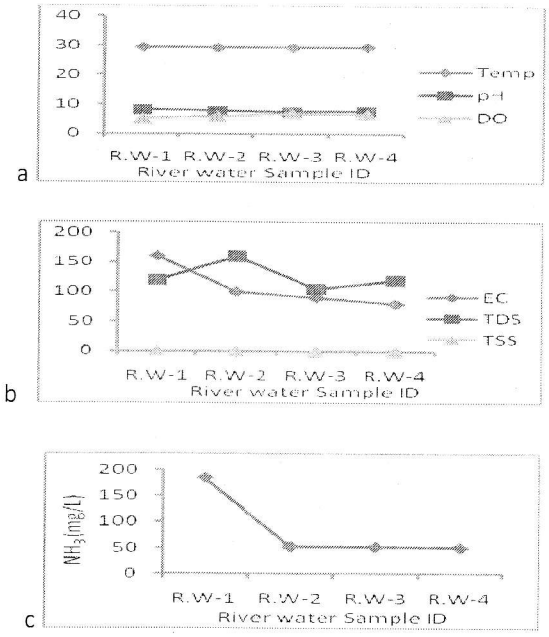


**Figure 4:** The variation of physicochemical properties (a-Temp, pH, DO, b-EC, TDS, TSS, c- $NH_3$), of river water.

Table 2. Descriptive statistics of physicochemical properties of wastewater samples with DoE standard (1997)

| Parameters | Maximum | Minimum | Mean | Std deviation (±) | DoE standard |
|---|---|---|---|---|---|
| Temp. ($^0$C) | 38.4 | 33.6 | 35.93 | 1.76 | 40 |
| pH | 10.2 | 8 | 8.82 | 0.74 | 6.5-8 |
| DO (mg/L) | 7.24 | 5.07 | 6.07 | 0.84 | 4.5-8 |
| EC ($\mu$s/cm) | 3290 | 550 | 1432.5 | 884.77 | 1200 |
| TDS (mg/L) | 1380 | 210 | 622.75 | 365.23 | 2100 |
| TSS (mg/L) | 5.312 | 0.148 | 1.02 | 1.742 | 150 |
| $NH_3$ (mg/L) | 418.32 | 20.16 | 163.18 | 166.80 | 50 |
| $PO_4^{3-}$ (mg/L) | 3.708 | 0.367 | 1.794 | 1.32 | 30 |

Comparative analysis to determine the level of pollution and possible sources

*Comparison of the various parameters of wastewater with standards for industrial waste (DoE, 1997)*

The average values of the various parameters of the wastewater of AECCL with the standards for industrial waste (DoE 1997) are shown in Table-2. The results showed that although the average values of the most of the parameters such as temperature, pH, DO, TDS, TSS of wastewater lies near or within the DoE standards but, the data of the few sampling points cross the standard limit. Further, it is found that the concentrations of ammonia and electrical conductivity of wastewater are significantly higher than the DoE standards. Similar types of results were observed in the wastewater of Polash and Ghorasal urea fertilizer factories (Islam *et al.* 2010).

Table 3. Descriptive statistics of physicochemical properties of the water of the Meghna River with DoE standard (1997)

| Parameters | Maximum | Minimum | Mean | Std deviation (±) | DoE standard for drinking water | DoE standard for fishing water |
|---|---|---|---|---|---|---|
| Temp.($^0$C) | 29.5 | 29.3 | 29.4 | 0.09 | 20-30 | 20-30 |
| pH | 8.2 | 7.5 | 7.8 | 0.29 | 6.5-8.5 | 6.5-8.5 |
| DO (mg/L) | 6.88 | 5.16 | 6.15 | 0.77 | 6 | 4 |
| TDS (mg/L) | 160 | 105 | 126.25 | 23.58 | 1500 | |
| TSS (mg/L) | 1.524 | 0.168 | 0.717 | 0.58 | 100 | |
| $NH_3$ (mg/L) | 184.45 | 51.18 | 85.43 | 66.01 | 0.5 | 3 |
| $PO_4^{3-}$ (mg/L) | 2.911 | 0.368 | 1.91 | 1.35 | 6 | |

*Comparison of the various parameters of river water with standards for drinking water and fish culture.*

The average values of the various parameters of the river water of the Meghna with the drinking water and fish culture standards (DoE, 1997) are shown in Table-3. The results showed that although the average values of the most of the parameters such as temperature, pH, DO, TDS, TSS and phosphate of river water lies near or within the DoE standards but, the data at the discharge point of wastewater into the river exceed the standard limit. Further, the concentration

of ammonia of river water around 200 and 30 times higher compare to the drinking water and fishing standards, respectively.

*Comparison of the various parameters of the Meghna river water with the Kushiara river water*
The concentration of the various parameters of the Meghna river water was compared with the Kushiara river water which is near the Natural Gas Fertilizer Factory LTD(NGFFL), Fenchuganj, Sylhet (Alam and Hossain 2009). Similar types of results were observed between the river water of Meghna and Kushiara except ammonia. Significantly higher concentration of ammonia was observed in the river water of the Meghna compare to the Kushiara, the reason might be that wastewater from NGFFL discharges into the Kushiara River after the removal of ammonia by treatment.

## Conclusions

Ashuganj Fertilizer and chemical company limited (AFCCL) produces prilled urea fertilizer using different types of chemicals. In this study, these chemical containing wastewater has been studied to measure their pollution level for the surrounding terrestrial and water body. The results show that wastewater from the factory contains high pH, electrical conductivity and ammonia. Main pollutant from the factory is ammonia with much higher concentration than that of the standard limit of DoE. The high pH makes the wastewater alkaline in nature which increases the toxicity of ammonia. So, it is essential to control the pH and ammonia of the wastewater from the factory. Although the values of other parameters in some cases were lower than the allowable limits, the continued discharge of the effluents in the river may result in severe accumulation of the contaminants and this may affect the lives of the people.

It also may be noted that ammonia concentration in soil samples that were collected from inside the factory was comparatively higher than downstream area as it is far away from the factory. This high concentration occurs due to leakage of ammonia or urea during production and transportation of raw materials and fertilizer. This high level of ammonia in the waste water and soil deteriorated the quality of river water of the Meghna. The river water contains several hundreds times higher ammonia concentration than DoE standard limit which may cause toxicity to fish and other aquatic organisms. Further, significantly higher concentration of ammonia was observed in the river water of the Meghna compare to the Kushiara, the reason might be that wastewater from NGFFL discharges into the Kushiara River after the removal of ammonia by treatment. It is therefore recommended that the disposal of improperly treated or untreated wastewater should be stopped and repaired the leakage of the fertilizer production plant to save the river water of the Meghna from further deterioration.

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