RESEARCH ARTICLE OPEN ACCESS

Impacts of Effluents on Physico-chemical Parameters of the Halda River Water

Mohammad Saydul Islam Sarkar[1], Md. Ashraful Azam Khan[2], Md. M. Maruf Hossain[3], Nazmul Hassan[4]

[1]Department of Oceanography, University of Chittagong, Chittagong-4331, Bangladesh
Email: saydul76@gmail.com
[2]Department of Fisheries, University of Chittagong, Chittagong-4331, Bangladesh
[3,4]Institute of Marine Sciences, University of Chittagong, Chittagong-4331, Bangladesh

Abstract:

The Halda River is one of the most important natural breeding ground of carp fishes in South Asia as well as Bangladesh. The study was carried out to analyze the physico-chemical parameters of the effluent discharged by the Asian Paper Mill & the physico-chemical changes in the water of Halda River with the addition of waste water from the Asian Paper Mill. Water samples from the freshwater resources were collected from different points and tide conditions and at different seasons for continuous monitoring during 2011. The data analyzed in different methods were followed during the study period like Argentometric Methods (APHA, 1976) for Chloride determination, Standard Methods (APHA, 1976), Spechtophotometric methods for Nitrate and Phosphate determination, Winkler methods for Dissolved Oxygen analyzed. SPSS software was used for data analysis. Test of Significance (ANOVA) also done for statistical data analysis. The collected samples were analyzed for the following parameters: temperature, total suspended solids (TSS), total solids (TS), total dissolved solids (TDS), turbidity, pH, total alkalinity, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate-N, Phosphate-P. The mean values of parameters were Air temp.- 26.83 ^{0}C, Water temp.- 25.67 ^{0}C, TSS- 3.37 mg/L , TS- 837.95 mg/L , TDS -835 mg/L, Turbidity - 7.42 cm, Soil P^H -7.72, Water P^H-8.13, Alkalinity - 140.25 mg/L, Chloride -43.53 mg/L, DO- 2.55 mg/L, BOD_5 - 277.42 mg/L, COD - 1077 mg/L, NO_3^- - 0.19µgm/L, PO_4^-- 0.08 µgm/L. The finding results shows the high values of T.S, T.D.S, D.O, B.O.D, C.O.D, Nitrate, Phosphate which is quite high with standards value for industrial effluent (EQS, 1991) for Bangladesh. The data showed the water quality slightly differs in monsoon and post-monsoon than winter season. Apart from destroying the quality of water, these hazardous chemicals from paper mills cause irreparable damage to the aquatic flora and fauna. Steps must be taken to save the Halda River from getting polluted from the industrial effluent.

Keywords **- Impact, Effluent, Physico-chemical, Parameter, Discharge, etc.**

INTRODUCTION

The paper and pulp industry in Bangladesh is considered as one of the important manufacturing sectors. With the advent of computers, the usage of paper in offices and other commercial establishments has reduced drastically. However paper continues to be used in: newsprint, printing and writing paper, uncoated free-sheet, coated paper, household and sanitary paper, packaging paper and specialty papers.

Paper and pulp industries cause water, air and solid waste pollution. Water is an integral part of operations within the paper and pulp industries and on average, the paper and pulp industries release tens of millions of wastewater per day. The waste water is fortified with various toxic chemicals like Volatile Organic Compounds (VOCs) such as terpenes, alcohols, phenols, methanol, acetone, chloroform, methyl ethyl ketone; detergents and surfactants; dyes and pigments; acids; and alkaline solutions. The United States Environment Protection Agency (EPA) makes it mandatory that the waste water being discharged from the paper

and pulp industry must be suitably treated before being discharged into rivers, lakes and other water bodies.

The effluent is rich in thiols, sulphur dioxide, sulphites and sulphides and this imparts a strong sulphuric stench to the effluent. Apart from this, it also contains fibres, and resins. The waste water is also inclusive of bleaching agents such as hydrogen peroxide, chlorine dioxide and caustic soda. Other pollutants include whitening agents such as kaolin, calcium carbonate, talc and titanium dioxide

Apart from destroying the quality of water, these hazardous chemicals cause irreparable damage to the aquatic flora and fauna. These chemicals are accumulated in fishes, which in turn are consumed by birds, and animals like otter and mink. This leads to a condition called "Biological Accumulation" which is described as the accumulation of elements and compounds of harmful substances in the tissues of living organisms. These chemicals are persistent in the food chain and move up from one level to another.

Another significant threat seen from the paper and pulp effluent is the high Biological Oxygen Demand (BOD) nature of the effluent. BOD is indicative of the concentration of biodegradable organic matter present in water samples. It is used to infer the quality of water and assess the degree to which the water sample has been polluted. A high level of BOD is indicative of reduced levels of Dissolved Oxygen (DO) and is not conducive for the growth and sustenance of aquatic life.

Chlorine and its derivatives are extensively used in the paper industry in the bleaching process. When these chlorine atoms react with the organic matter present in the pulp, they form organochlorine compounds known as dioxins and furans. These chemical compounds are toxic, carcinogenic, and highly persistent in nature. They have a tendency to accumulate in soil sediments as well as biological tissues leading to biological accumulation.

Some of the air pollutants released by the paper industry include carbon dioxide, nitrous oxides, sulphur dioxides, carbon monoxide, ammonia, VOCs and particulate matter like ash and dust. These pollutants contribute to the growing environmental concerns such as Ozone Depletion, Acid Rains, and Global Warming.

Solid waste produced by paper and pulp industries is disposed in a landfill. The nature of the solid waste produced by the paper and pulp industry is highly hazardous as it contains residual inks, dyes, coatings, starches, pigments, resins, fatty acids, paper fibres and kaolin. The resulting sludge is disposed in a landfill with the result that large amounts of land are used up to contain this waste. Apart from this, there is a significant risk of trace contaminants accumulating in the soil or the leachate running off into the nearby lakes and rivers or even contaminating the ground water table.

In the last decade of the Twentieth Century the age of spectacular progress of science and tecnology material affluence and sofistication in life, mankind faces the fear of gradual extinction. And this fear comes from the environment which provides man with necessary conditions and nuclear war has been greatly overcomewith an unimaginable radical change in the world order in the late 80s and early 90s. But natures growing adversly prevents us from being much optimistic about future. It has now been identified with the question of our existence.

Nature always requires a state of equilibrium. Favorable condition appeared in nature before man got his biological existance. Since then man has been growing up and evolving towards upward lines harnessing the resources of nature and fighting against its advers forces. This harnessing had no serious effect on nature before the introduction of modern industry based civilization and production of nuclear armaments.

Modern civilization is marked with the establishment of heavy industry that produce materials for better, faster and comfortable life. There is no doubt that it is science and technology that has brought man to this stage of prosperity. Man’s strenuous efforts to improve his life style has put sofistication to has life. But in doing so, man

has become consciously or unconsciously the greatest enemy of nature and environment. The more we are being developed materially the more we are doing harm to the environment on which depends our existence and vice varsa. We see nature's avenging attitude towards us. The results of increasing secretion of 'green house gases' that cause rifts in Ozone layer, global worming and increase in the sea level, acid rain, deplition of forests and pollution of air, water, food and soil need no longer be over exaggerated.

Now the issue of the environmental pollution has been a matter of grave concern common to the whole mankind. No would suggest to turn the clock of history by postponing scientific research and development works. Rigorous lows should be made and enforced in order to prevent reckless consumption or destruction of the elements of nature. There should be separate places awaya from locality for dumping by-products and wastes from factories. There should be establish the effluent treatement plant of all the factories. All this measures are, however, temporary and have limitations. The elements harmful for the environment, whenever left or kept have bad effects on the global environment at large.

It is knowing that industrialization to be responsible for increasing the environmental pollution. But we should not ignore the related fectors when we think interm of global context. It is a fact that a great imbalance in the world economic environment has been created due to unequal industrial development in different part of the world. Transfer and exchange of wealth among different nations being imbalanced exploitation prevails. This exploitation accompanied by various socio-economic and political factors and background has included poverty, illiteracy and unhealthy situation as the elements of the environmental of undeveloped and developing countries. With the continuation of the process of exploitation propagation, against industrialization and development work for environmental protection, is proved to be hollow and fruitless for millions suffering from want of primery requerments needed for living a moderate life.

Whereas over consumption and luxury in development world is acting severely upon environment, in backward regions, problems like deforestation and destruction of natural resources are directly linked with poverty ignorance, over-production and mismanagement, poor people struggling to keep body and soul together tend to rather are force to destroy natural resources for their livelihood.

It is often observed that the suggestions and plants framed for environmental protection and disaster prevention. In the third world countries are short termed and in many cases fail to fulfil the proper requerments. One of the main factors behind it is to follow the forign suggestions too. So, scientist and exparts of these countries should try to find technologies appropriate to their own context.

In stand of the global environmental condition if we look at the environmental situation of Bangladesh we also find that the level of environmental pollution of this country is not so good. Among the different types of pollution, water pollution has reached to an allarming possition, water is the most useful resource on earth economically, biologically and culturally. Without water, live can not survive. With a marked rise in pollution, a rapid growth of towns and industries and a great increase in irrigation, the demand for pure water is gradually increasing. On the other hand the pollution of both surface and ground is rising everywhere. The industries (Such as Paper Mills, Rayon Mills, Urea Fertilizer, Tanneries, Oil refineries, Soap factories, Fish & Meat processing factories, TSP complex, Cement Clinker and Grinding company Ltd, Dry dock, Chemical industries etc.) those demand so much clear water, themselves, happened to be worst polluters of rivers. Usually these industries are established on bank of the river or on a big canal which are connected to the river. Where water is easily avilable for power and and for manufacturing process. Ironically enough the same industries discharge long quantities of their liquid and solid trade wastes, as well as crude sewage into the river. as a result, in way of the rivers, fishes which are formally known to be aboundant have now disappeared and even water supply are in denger.

Generally the potential impact of pollutants in more on the aquatic organisms than on the terrestrial organisms, because in the hydrosphere, pesticides and such other substances are transported to a greater distance and hance many more nontarget organisms are likely to be exposed to them in the terrestrial environment. Moreover, unlike the terrestrial environment in aquatic environment, the body of organisms is bathed by the medium containing the toxicant. Bangladesh is a riverine and developing country. In this country, majore pollution is caused by the industrial wastes, sewage and agricultural wastes. To save the productivity and other resources of our water body, it is very essential to work about the Environmental Impact Assessment (EIA) and the effect of pollution upon the growth, development, reproduction and other processes of life cycle of aquatic organisms.

MATERIALS AND METHODS

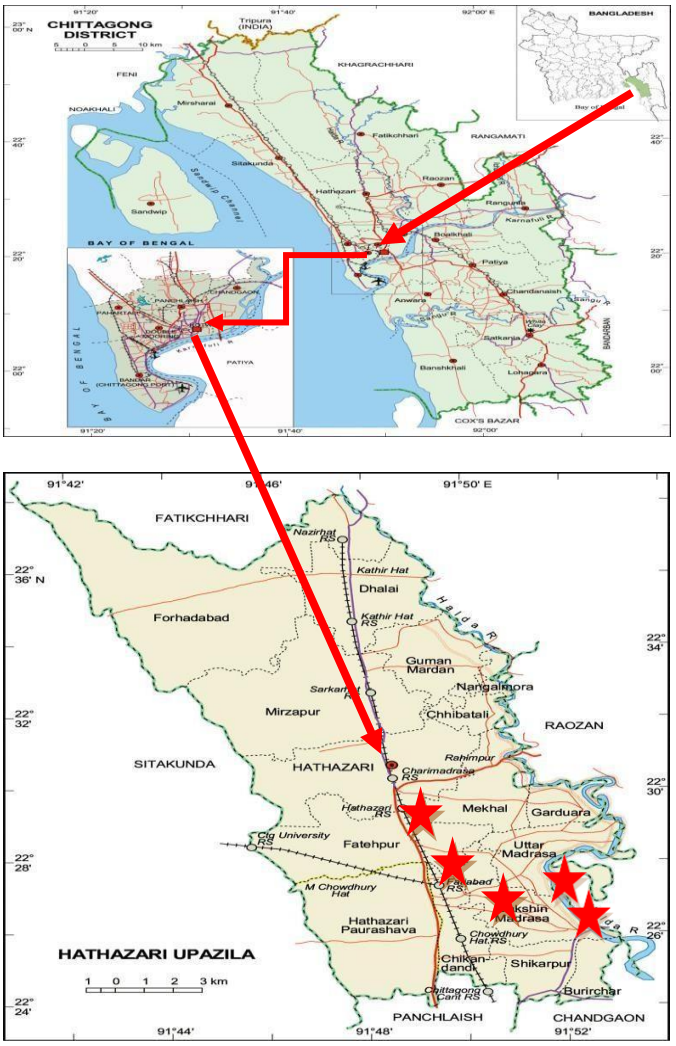
Monthly sampling was carried out from October to December, 2011 at 5 stations, 3 at the effluent discharged drain, 1 at the meeting place and another was the up-stream from the discharge drain. Detail description of the industries and location of the stations has been illustrated in the earlier chapters. Water samples were collected during low tide.

Sampling stations

Asian Paper Mill up to 7 kilometers far away from Halda River. The wastes from different plants of these mills come out by different drains and combined discharge through a main effluent drain of the mill. Then the canal goes through Talukder Para, Nehalpur, Fokerer Vita and meet with Boalia canal in fisherman folk (Jele Para). Then the canal is going through the nearest urban area and opened in the 3-4 kilometer away Madarsah canal. Then Madarsah canal opened in the Halda River in Madaripul. It has been studied to assess the impact of the effluent discharge from this mill into the water body of the Halda River. From the area, monthly sampling was made from October, 2011 to December, 2011 at five stations (Map). The station 5 was located one kilometer up stream to the station 4 (where the effluent meets with Halda) and considered as controlled station. So, during sampling period, there was no effect of effluent of Asian Paper Mills in this station (station 5, controlled).

Table 1 Sampling stations

Stations number	Stations name
Station- 1	Main effluent drain of the mill
Station- 2	Nehalpur (Nanderhat)
Station- 3	Boalia canal
Station- 4	Madarsha canal
Station- 5	North Madrasha



Map 1 Showing sampling stations (star marks, ★)

Description of the sampling stations

Station-1

All effluent opened into a big drain which ultimately opened to the nearest canal. It is adjacent with Hathazari road. Before mixing with canals water, effluent was collected from the big drain. This location has been considered as station-1.

Station-2

The station 2 was located at the Nehalpur (Nanderhat). It is one and half kilometers down to the station 1. It is situated on an urban area.

Station-3

Station 3 was located at the meeting place of the main drain and Boalia canal. It is situated in an agricultural field. It is also one and half kilometers down from station 2.

Station-4

This station was located near the Madaripul sluice gate, where Madarsah canal meet with the Halda River. This area called is Madaripul. It is also four kilometers down from station 3.

Station-5

The station 5 was located at the North Madarsah. It is located one kilometer up stream to the station 4 (where the effluent meets with Halda) and considered as controlled station. So, during sampling period, there was no effect of effluent of Asian Paper Mills in this station.

Collection of samples

Water samples were collected by different containers. For Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD), water samples were collected in BOD bottles of varies capacity each. Samples were also collected with clear plastic containers of five liters capacity each, for measuring all the physical, chemical and Bio-chemical parameters except DO and BOD.

Preservation of samples

Samples collected for DO in BOD bottles were treated with 1 ml of Manganese Sulphate solution followed by 1 ml of Potassium Iodide (KI) Azide reagent in the field. The bottles were turned upside down several times for through mixing of the contents. The bottles were stoppered in such away, so that no air bubble left. All the bottles with samples (including DO bottles) were then placed in wooden boxes to avoid direct sunlight and thus the samples were transported to laboratory and was preserved (except BOD samples) at 4^0 C very carefully before analysis (WHO, 1982).

METHODS OF ANALYSIS

Air temperature

Air temperature was measured by a glass Celsius thermometer.

Water temperature

Water temperature was measured by also a glass Celsius thermometer.

Total Suspended Solids (T.S.S)

At first a filter paper was oven dried for moisture free at 60^0 C for 30 minutes. Then it keeps into desiccators for cooling and then it weighted by an electric balance. Then a thoroughly mixed 100 ml samples was filtered through the weighted filter paper. The filter paper was allowed to dry completely and reweighted. The change in weight is multiplied by 10 thus total suspended solids (T.S.S) in 1 liter of water sample was obtained (Andrews, 1972).

Total Dissolved Solids (T.D.S)

A porcelin Crucible was weighted and was placed on steam bath, then 100 ml of filtered samples from the T.S.S experiment was placed in this Crucible. Evaporation took place slowly up to dryness. After cooling the crucible was placed in a disiccator and was weighted. The change in weight is multiplied by 10 thus total dissolved solids (T.D.S) in 1 liter of water sample was obtained (Andrews, 1972).

Total Solids (T.S)

To obtain the total solids (T.S), the measured value of total suspended solids (T.S.S) and total dissolved solids (T.D.S) were added.

Turbidity

Turbidity was measured by Secce Disk of visual method.

RESULTS AND OBSERVATIONS

Air temperature

Station – 1

In the research area air temperature of station-1 fluctuated between 35^{0}C to 16^{0}C. The temperature was found to reach its maximum value (35^{0}C) in Monsoon, (September, 2011) with ups and down from winter (December, 2011). From the maximum value (35^{0}C) it reached to its minimum value (16^{0}C) in the winter season. The average value of this station was 27^{0}C.

Station – 2

The air temperature of station-2 varied between 35^{0}C to 15^{0}C. The temperature started to decrease from the monsoon and attained to its minimum value (15^{0}C) in winter. From the maximum value it stated to decreased and reached to its minimum value in winter. The average value of this station was 26.66^{0}C.

Station – 3

The air temperature of station-3 ranged between 32^{0}C to 14^{0}C. The temperature attained to its maximum value (32^{0}C) in monsoon, and the minimum value was (14^{0}C). It is observed that from the maximum value in monsoon, the temperature started to decreased and attained to its minimum value in winter. The average value of this station was 26^{0}C.

Station – 4

The air temperature of station-4 fluctuated between 34^{0}C to 16^{0}C. The maximum value was observed in the monsoon and minimum in winter. In this case also the temperature decreased gradually from maximum value and reached to the minimum. The average value of this station was 27.27^{0}C.

Station– 5

The air temperature of station-5 ranged between 34^{0}C to 15^{0}C. The temperature attained to its maximum value (34^{0}C) in monsoon, and the minimum value was (15^{0}C). It is observed that from the maximum value in monsoon, the temperature started to decreased and attained to its minimum value in winter. The average value of this station was 27.33^{0}C.

Statistical analysis

In the statistical analysis the data shows the air temperature has significance difference (P> 0.001) with various seasons and stations. Shows table (Table- 6) and graphically (Fig. 1).

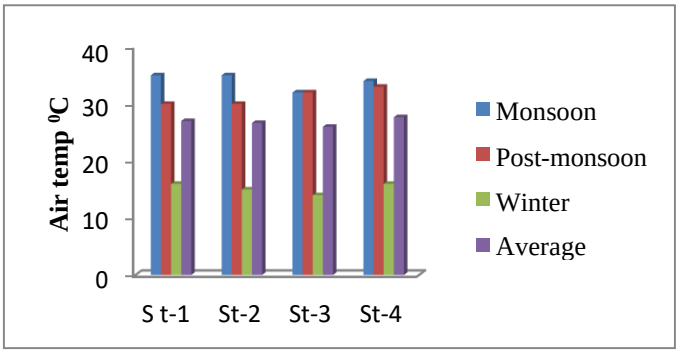


Figure 1 Air temperature of station- 1, 2, 3, 4 & their average value

Water temperature

Station – 1

In the research area water temperature of station-1 fluctuated between 36^{0}C to 12^{0}C. The temperature was found to reach its maximum value (36^{0}C) in Monsoon (September, 2011) with ups and down from winter (December, 2011). From the maximum

value (36^0C) it reached to its minimum value (12^0C) in the winter season. The average value of this station was 26.33^0C.

Station – 2

The water temperature of station-2 varied between 35^0C to 13^0C. The temperature started to decrease from the monsoon and attained to its minimum value (13^0C) in winter. From the maximum value it stated to decreased and reached to its minimum value in winter. The average value of this station was 26.33^0C.

Station – 3

The water temperature of station-3 ranged between 30^0C to 10^0C. The temperature attained to its maximum value (30^0C) in monsoon, and the minimum value was (10^0C). It is observed that from the maximum value in monsoon, the temperature started to decreased and attained to its minimum value in winter. The average value of this station was 24^0C.

Station – 4

The water temperature of station-4 fluctuated between 32^0C to 14^0C. The maximum value was observed in the monsoon and minimum in winter. In this case also the temperature decreased gradually from maximum value and reached to the minimum. The average value of this station was 26^0C.

Station– 5

The water temperature of station-5 ranged between 31^0C to 14^0C. The temperature attained to its maximum value (31^0C) in monsoon, and the minimum value was (14^0C). It is observed that from the maximum value in monsoon, the temperature started to decreased and attained to its minimum value in winter. The average value of this station was 25.67^0C.

Statistical analysis

In the statistical analysis the data shows the water temperature has significance difference ($P< 0.001$) with various seasons and stations. Shows table (Table- 6) and graphically (Fig. 2).

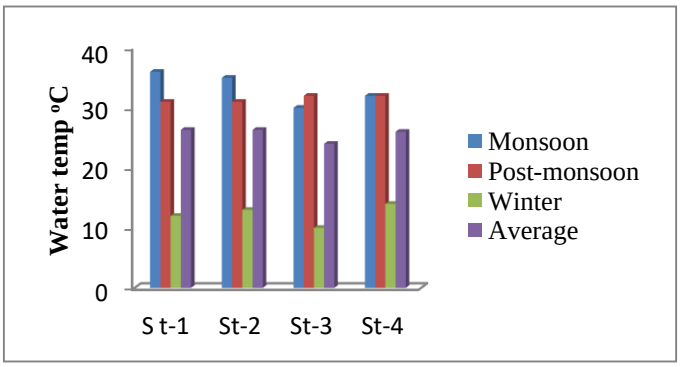


Figure 2 water temperature of station- 1, 2, 3, 4 & their average value

Total suspended solids (TSS)

Station – 1

The total suspended solid of station – 1 ranged between 5.81 mg/L to 3.92 mg/L. The value started to decrease gradually from monsoon to winter. Its maximum value was 5.81 mg/L. From the maximum value it begun to decrease and attained to its minimum value 3.92 mg/L in winter. The average value of this station was 4.78 mg/L.

Station – 2

The total suspended solid of station – 2 ranged between 4.98 mg/L to 3.77 mg/L. The value started to decrease gradually from monsoon to winter and it showed its minimum value 3.77 mg/L in winter. From the maximum value it begun to decrease and attained to its minimum value 3.77 mg / L in winter. The average value of this station was 4.30 mg/L.

Station-3

The total suspended solid of station – 3 varied between 3.49 mg/L to 2.81 mg/L. The value started to decrease gradually from monsoon to winter and it showed its minimum value 2.81 mg/L in winter. From the maximum value it begun to decrease and attained to its minimum value 2.81 mg / L in winter. The average value of this station was 3.07 mg/L.

Station – 4

The total suspended solid of station- 4 varied between 1.72 mg/L to 0.72 mg/L. The value suddenly decreased in post-monsoon but it also suddenly increased in winter. Maximum value of this station showed in monsoon 1.72 mg/L and the minimum value was 0.72 mg/L in post-monsoon. The value of TSS in this station in winter was 1.52 mg/L. The average value of this station was 1.32 mg/L.

Station– 5

The total suspended solid of station- 5 varied between 1.33 mg/L to 0.68 mg/L. The value suddenly decreased in post-monsoon but it also suddenly increased in winter. Maximum value of this station showed in monsoon 1.33 mg/L and the minimum value was 0.68 mg/L in post-monsoon. The value of TSS in this station in winter was 0.33 mg/L. The average value of this station was 0.78 mg/L.

Statistical analysis

In the statistical analysis the data shows the TSS has no significance difference (P> 0.05) with various seasons and stations.

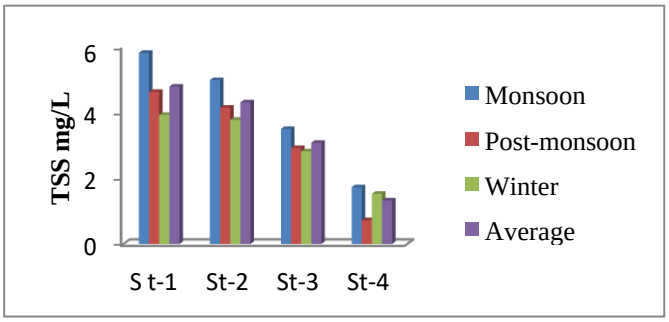


Figure 3 Total Suspended Solids of station- 1, 2, 3, 4 & their average value

Total solids (TS)

Station – 1

The total solid of station – 1 ranged between 1347.81mg/L to 1292.92 mg/L. The maximum value was found 1347.81 mg/L in monsoon (September, 2011) and the minimum value 1292.92 mg/L was found in winter (December, 2011). The value of TS in post-monsoon was 1325.62 mg/L. From the maximum value it started to decrease and reached to its minimum value 1292.92 mg/L in winter. The average value of this station was 1322.12 mg/L.

Station – 2

The total solid of station – 1 ranged between 1000.98 mg/L to 971.77 mg/L. The maximum value was found 1000.98 mg/L in monsoon (September, 2011) and the minimum value 971.77 mg/L was found in winter (December, 2011). The value of TS in post-monsoon was 984.14 mg/L. From the maximum value it started to decrease and reached to its minimum value 971.77 mg/L in winter. The average value of this station was 985.63 mg/L.

Station – 3

The total solid of station – 1 ranged between 746.49 mg/L to 705.81 mg/L. The maximum value was found 746.49 mg/L in monsoon (September, 2011) and the minimum value 705.81 mg/L was found in winter (December, 2011). The value of TS in post-monsoon was 722.91 mg/L. From the maximum value it started to decrease and reached to its minimum value 705.81 mg/L in winter. The average value of this station was 725.07 mg/L.

Station – 4

The total solid of station- 4 varied between 321.72 mg/L to 310.72 mg/L. The value suddenly decreased in post-monsoon but it also suddenly increased in winter. Maximum value of this station showed in monsoon 321.72 mg/L and the minimum value was 310.72 mg/L in post-monsoon. The value of TS in this station in winter was 324.52 mg/L. The average value of this station was 318.99 mg/L.

Station– 5

The total solid of station- 5 varied between 150.33 mg/L to 97.68 mg/L. The value suddenly decreased in post-monsoon but it also suddenly increased in winter. Maximum value of this station showed in monsoon 150.33 mg/L and the minimum value was

97.68 mg/L in post-monsoon. The value of TS in this station in winter was 324.52 mg/L. The average value of this station was 128.45 mg/L.

Statistical analysis

In the statistical analysis the data shows the TS has no significance difference (P> 0.05) with various seasons and stations.

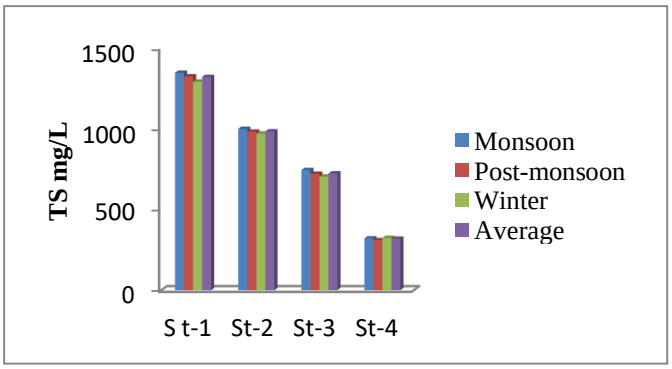


Figure 4 Total Solids of station- 1, 2, 3, 4 & their average value

Total dissolved solids (TDS)

Station – 1

The total dissolved solid of station– 1 ranged between 1342 mg/L to 1289 mg/L. The maximum value was found 1342 mg/L in monsoon (September, 2011) and the minimum value 1289 mg/L was found in winter (December, 2011). The value of TDS in post-monsoon was 1321 mg/L. From the maximum value it started to gradually decrease and reached to its minimum value 1289 mg/L in winter. The average value of this station was 1317.33 mg/L.

Station– 2

The total dissolved solid of station– 2 ranged between 996 mg/L to 968 mg/L. The maximum value was found 996 mg/L in monsoon (September, 2011) and the minimum value 968 mg/L was found in winter (December, 2011). The value of TDS in post-monsoon was 980 mg/L. From the maximum value it started to gradually decreased and reached to its minimum value 968 mg/L in winter. The average value of this station was 981.33 mg/L.

Station- 3

The total dissolved solid of station– 3 ranged between 743 mg/L to 703 mg/L. The maximum value was found 743 mg/L in monsoon (September, 2011) and the minimum value 703 mg/L was found in winter (December, 2011). The value of TDS in post-monsoon was 720 mg/L. From the maximum value it started to gradually decreased and reached to its minimum value 703 mg/L in winter. The average value of this station was 722 mg/L.

Station – 4

The total dissolved solids of station- 4 varied between 330 mg/L to 310 mg/L. The value suddenly decreased in post-monsoon but it also suddenly increased in winter. Maximum value of this station showed in monsoon 330 mg/L and the minimum value was 310 mg/L in post-monsoon. The value of TDS in this station in winter was 323 mg/L. The average value of this station was 321 mg/L.

Station–5

The total dissolved solid of station– 5 ranged between 149 mg/L to 97 mg/L. The maximum value was found 149 mg/L in monsoon (September, 2011) and the minimum value 97 mg/L was found in winter (December, 2011). The value of TDS in post-monsoon was 137 mg/L. From the maximum value it started to gradually decreased and reached to its minimum value 97 mg/L in winter. The average value of this station was 127.67 mg/L.

Statistical analysis

In the statistical analysis the data shows the TDS has no significance difference (P> 0.05) with various seasons and stations.

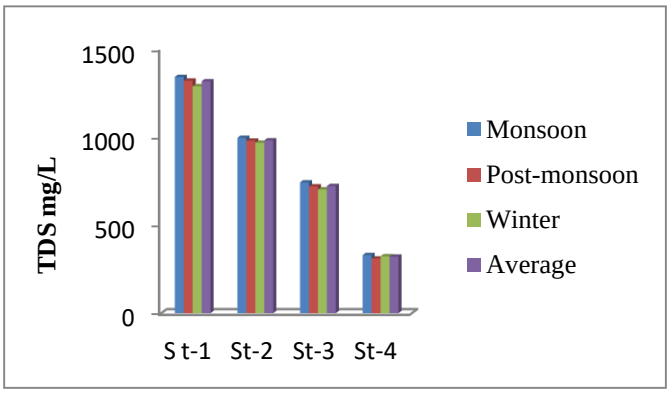


Figure 5 Total Dissolved Solids of station- 1, 2, 3, 4 & their average value

Turbidity

Station– 1

The turbidity of station–1found was 4.00 cm, 3.00 cm and 3.00 cm in respectively monsoon, post-monsoon and winter. These results were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. Higher turbidity found was post-monsoon and winter and the lower turbidity was found was the monsoon period. The average value of turbidity of this station was 3.33 cm.

Station– 2

The turbidity of station–2 found was 5.00 cm, 4.00 cm and 5.00 cm in respectively monsoon, post-monsoon and winter. These results were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. Higher transparency found was monsoon and winter (Both 5.00 cm) and the lower transparency was found was 4.00 cm in the post-monsoon period. The average value of turbidity of this station was 4.67 cm.

Station– 3

The turbidity of station–3 found was 5.00 cm, 8.00 cm and 9.00 cm in respectively monsoon, post-monsoon and winter. These results were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. Higher transparency found winter 9.00 cm and the lower transparency was found was 5.00 cm in the monsoon period. The transparency was gradually increased in the monsoon to winter. The average value of turbidity of this station was 7.33 cm.

Station– 4

The turbidity of station–4 found was 10.00 cm, 14.00 cm and 19.00 cm in respectively monsoon, post-monsoon and winter. These results were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. Higher transparency found in winter 19.00 cm and the lower transparency was found 10.00 cm in the monsoon period. The transparency was gradually increased in the monsoon to winter. The average value of turbidity of this station was 14.33 cm.

Station– 5

The turbidity of station–5 found was 12.00 cm, 24.00 cm and 32.00 cm in respectively monsoon, post-monsoon and winter. These results were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. Higher transparency found in winter 32.00 cm and the lower transparency was found 12.00 cm in the monsoon period. The transparency was gradually increased in the monsoon to winter. The average value of turbidity of this station was 22.67 cm.

Statistical analysis

In the statistical analysis the data shows the turbidity has no significance difference ($P > 0.05$) with various seasons and stations.

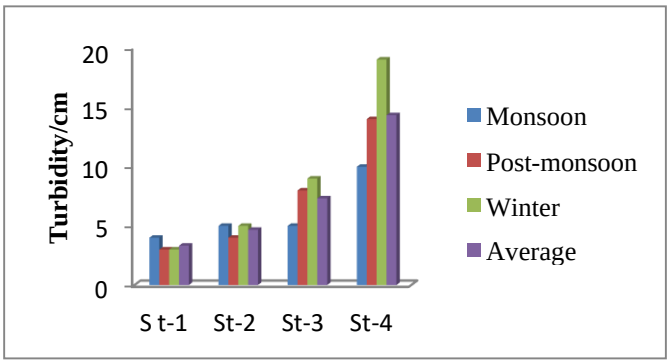


Figure 6 Turbidity of station- 1, 2, 3, 4 & their average value

DISCUSSIONS

Air temperature

During the period of observation, the maximum and the minimum air temperature of the affluent discharged area and near the River Halda were recorded as 35°C and 14°C in the months of September, 2011 and December, 2011 respectively at station-1 & 3. But the standard values for the industrial effluent of Environmental quality Standards (EQS) for Bangladesh are 30°C and 35°C in the winter and summer months respectively. The highest value of air temperature (35°C) maintains the EQS value but the minimum value (14^0) does not maintain the EQS value.

The fluctuation of air temperature of stations (1, 2, 3 and 4) was more or less seasonal in the present investigation. Khan (1976), Quader (1976) and Hossain (1992) studied the air temperature of the karnafully River and observed seasonal variation. The pattern of seasonal variation in temperature at station 1, 2, 3 and 4 was visualized with the observations of the above authors.

The variations of air temperature in controlled area (station-5) and effluent discharged area were closer. But the difference of air temperature was noticed among the temperature of effluent, effluent discharged area and controlled area, the present work does not coincide with the work of Hossain (1992) who worked on the Chittagong Urea Fertilizer Limited (CUFL).

Klein (1962), Moore (1960), UNEP & WHO (1990) and Hossain (1992) stated that many industries were the cause of increase the air temperature of the surrounding area in which their effluent was dumped. The present work similitude's with above authors.

Water temperature

During the period of observation, the maximum and the minimum temperature of the affluent before discharged into the River Halda were recorded as 36°C and 12°C in the months of September, 2011 and December, 2011 respectively at station-1. But the standard values for the industrial effluent of Environmental quality Standards (EQS) for Bangladesh are 40°C and 45°C in the winter and summer months respectively. The highest value of temperature (36°C) did not maintain the EQS value. Besides station- 1, the fluctuation in water temperature other three stations (2, 3 and 4) were more or less seasonal in the present investigation. Khan (1976), Quader (1976), Paul (1981), Hossain *et. al* (1988) and Hossain (1992) studied the water temperature of the karnafully River and observed seasonal variation. The pattern of seasonal variation in temperature at station 2, 3 and 4 was visualized with the observations of the above authors.

The variations of temperature in controlled area (station-5) and effluent discharged area were closer. But the difference of temperature was noticed among the temperature of effluent, effluent discharged area and controlled area, the present work coincides with the work of Hossain (1992) who worked on the Chittagong Urea Fertilizer Limited (CUFL).

Klein (1962), Moore (1960), UNEP & WHO (1990) and Hossain (1992) stated that many industries were the cause of increase the temperature of the water body in which their effluent was dumped. The present work similitude's with above authors.

Total suspended Solids (TSS)

The maximum (5.81 mg/L) and the minimum (0.72 mg/L) values of total suspended solids were

recorded in station-1 and station-4 in the months of September, 2011 and December, 2011 respectively among the four stations.

The average values of station-1 were comparatively always higher than the other stations (2, 3, 4 and 5) average value during the investigation period. Even the lowest value (3.92 mg/L) of station-1 was much higher than the highest values of the stations (3, 4 and 5). These high values of TSS at station-1 may be due to the effluents which contained several types of organic and inorganic material with it. The low values in other, stations were due to the dilution of the effluent with other water. The value of TSS in controlled station-5 was much lower than all other stations.

Quader (1976) reported that the TSS of the Karnafully River was high due to heavy silt in water. Hossain (1992) while working in the Karnafully River recorded 7.5 mg/L and 2.6 mg/L as the highest and the lowest values of TSS respectively, from the CUFL which have a lower values with the maximum (5.81 mg/L) and minimum (0.72 mg/L) TSS values of station -1 and 4 of the present investigation respectively.

The standard values for industrial effluent of EQS for Bangladesh is 1.50 mg/L but in the present investigation the effluent of Asian Paper Mills did not maintain the standard.

Total Solids (TS)

The values of total solids (TS) were always higher in station-1 than the other stations (2, 3, 4 and 5). The maximum (1347.81 mg/L) values of TS were recorded at station-1 and the minimum value (310.72 mg/L) was recorded at station-4 among the four stations during the period of investigation. The lowest value of these stations (1, 2, 3 and 4) was the higher for the controlled station-5 (Highest-150.33 mg/L, Lowest- 128.45 mg/L). Though the TS value in station-1 was higher than all other stations (2, 3, 4 & 5) in the present study it did not exceed the standard values (2250 mg/L) for industrial effluent of EQS for Bangladesh (1992). So, the water quality was not influenced by this TS value in the present investigation. The overall values of TS were higher in the monsoon season than all other season among the five stations during the period of investigation.

Total Dissolved Solids (TDS)

The maximum and the minimum total dissolved solids (TDS) in the five stations of the present study were 1342 mg/L and 1289 mg/L, 996 mg/L and 968 mg/L, 743 mg/L and 703 mg/L, and 330 mg/L and 310 mg/L, 149 mg/L and 97 mg/L in station-1, station-2, station-3, station-4 and station-5 respectively.

The values of TDS in station-1 were much higher than the other four stations (2, 3, 4 and 5) in the present investigation. But the values of TDS in any stations including station-1 did not exceed the EQS value during the period of investigation. The EQS value of TDS for Bangladesh is 2100 mg/L.

As the TDS value in the effluent of Asian Paper Mill (APM) in the present investigation was lower than the EQS value for Bangladesh, it can be said that the TDS of the effluent of the APM was not harmful for the water was well as biota of the Halda River.

Turbidity

The turbidity of the effluent was found to be always higher than the effluent discharged areas and controlled area. The results of turbidity were found by visual methods. For this reason the depth is reciprocal to the transparency of water. So, the depth is lower than the transparency is higher and the depth is higher than the transparency is lower. So, the maximum (32 cm) and the minimum (3 cm) values of transparency were recorded in station-5 and station-1 in the months of September, 2011, and December, 2011 respectively during the period of investigation. So, the result of turbidly was higher in station-1 and lower in station-5 among the all stations (1, 2, 3 & 4).

The maximum transparency of Karnafully River was 150 cm, Kasalong River was 66 cm, Matamuhuri River was 64 cm, Chingri River was

47 cm, Naf River was 26 and Bakkhali River was 16 cm, Ahmed *et. al* (2010).

The results of present investigation were much lower except Naf and Bakkhali River.

The values of turbidity were higher in the monsoon season than the other seasons in all stations during the investigation period, and were lower in the winter season. Nair *et. al* (1983) also found the same result.

CONCLUSIONS

Worldwide, the pulp and paper industry is the fifth largest consumer of energy, accounting for four percent of the entire world's energy use. The pulp and paper industry uses more water to produce a ton of product than any other industry.

Paper and pulp industries cause water, air and solid waste pollution. The article looks at the sources of pollution from a paper and pulp industry and steps being implemented to tackle this challenge.

The paper and pulp industries need to identify strategies which will effectively deal with the growing pollution problem. While the traditional system expects the environment experts to deal with this problem, it does little to solve the problem. Although there are various pollution prevention techniques, more R&D activities in the area of pollution control must be initiated. The entire paper and pulp industry has to view this challenge as the entire industry's responsibility and formulate appropriate plans to tackle pollution and make suitable use of the existing resources.

Paper sector in Bangladesh is growing very fast. Most of the mills are based on imported pulp and waste paper as raw materials. Very few of them have effluent treatment plants. Every year this sector produces several million tons of effluent that contaminates receiving water body. If this effluent is discharged directly, it will disrupt the ecological system. Therefore, it is very high time to revive these rivers and re-establish the ecological system through setting up of properly designed and functional ETP at each and every effluent producing industry.

Halda River water quality significantly varied with seasons, tide conditions and locations. From the location dependent variation it can be concluded that effect of sea water reaches up to the Kalurghat point. So there is possibility of destroying biodiversity of the Halda River by the intrusion of polluted Karnafuli River water in the pre-monsoon period at high tide. Due to this, spawning of carps is decreasing gradually and lesser quantities of fish eggs are being harvested nowadays (Islam, 2009).

Apart from destroying the quality of water, these hazardous chemicals from paper mills cause irreparable damage to the aquatic flora and fauna. These chemicals are accumulated in fishes, which in turn are consumed by birds, and animals. This leads to a condition called "Biological Accumulation" which is described as the accumulation of elements and compounds of harmful substances in the tissues of living organisms. These chemicals are persistent in the food chain and move up from one level to another.

The results from data analysis show that, the water is certainly unfit for drinking purposes without any form of treatment, but for various other surface water usage purposes, it still could be considered quite acceptable. But as we know, once a trend in pollution sets in, it generally accelerates to cause greater deterioration. So few years from now, serious water quality deterioration could take place. However, there could be gross differences in the test results of some samples at different places in the study area, which could limit the use of these data for sensitive policy issues. This study involves determination of physic-chemical parameters of surface water at different points.

RECOMMENDATIONS

- From the present study it is found that the Halda River water becomes polluted from Industrial sources. Industrial and municipal effluents must be discharged into the River after proper treatment (ETP). Many

industries have effluent treatment plants, but they are not using it.

- Steps must be taken to save the Halda River from getting polluted by the responsible industries and proper law should be passed and implemented, so that authority can take necessary action against the industries and bodies responsible for polluting the rivers.

- Government of Bangladesh should be taken proper action for making new national and regional policies and appropriate preventive measures on the basis of assessment data prior further deterioration of water quality.

- The Public awareness should be increased of the risk and affected areas so that they could ready to face the disaster due to Climate change.

- Pollution prevention involves initiating steps to reduce at the intensity of pollution at various levels. This can be accomplished by reducing the generation of wastes at its source, reusing and recycling the resources.

REFERENCES

1. *Ahmed, M. J., Haque, M. R., Ahsan, A., Siraj, S., Bhuiyan, M. H. R., Bhattacharjee, S. C and Islam, S. 2010. Physicochemical Assessment of Surface and Groundwater Quality of the Greater Chittagong Region of Bangladesh, Pak. J. Anal. Environ. Chem. Vol. 11, No. 2 (2010) 1.11.*

2. *Andrews, W.A., D.K. Moore and A.C. Leroy, 1972. A guide to the study of environmental pollution. Pointed in the U.S.A.*

3. *APHA (American Public Health Association), 1976. Standard Methods For the examination of water and waste water, 13th edition, 1976, Broadway, New York- 10019.*

4. *Environmental Quality Standards (EQS) for Bangladesh. 1991. Dept. of Environment, Govt. of Bangladesh. 28-31 pp.*

5. *Hosain, T. 1992. "Study on the environmental impact assessment (EIA) of the effluent discharged by the Chittagong Urea Fertilizer Limited (CUFL) on the Karnafully River Estuary." Unpublished M.Sc. thesis. Marine Sciences.*

6. *Islam, M.T. (2009). Livelihood Condition of spawn carp fishing community at the western part of Halda River, Chittagong, Bangladesh. 81pp.*

7. *Khan, Y. S. A., N. Mahmood. 1976. Preliminary observation on the hydrological condition of the Bay of Bengal off coast of Bangladesh. Journal of the Asiatic Society, Bangladesh (Sc.) 1 (2): pp.117-122.*

8. *Klein, L. 1962. "River pollution. 2. Causes and effects." butter worths. And Co. Ltd. London, 456 pp.*

9. *Hossain, M. M, 1988. Some water quality characteristics of the karnafully river estuary. Mahasagar – Bulletin of the National Institute of Oceanography 21: pp.183-188.*

10. *Moore, M., Ken Mcleod and Don Reed. 1960. "Fisheries: Conservation propagation regulation," published by Washington state department of Fisheries, 155-163 pp.*

11. *Paul, S. 1981. Effect of Oil pollution upon planktonic orgnaism of the Karnafully River-estuary. M. Sc. thesis Dept. of Marine Sciences, CU.*

12. *Quader Obaidul. 1976. Pollution of the Karnafully estuary and its effect on Apocryptes bato. M. Sc. thesis. Marine Science.*

13. *WHO & UNEP. 1990. Assessment of fresh water quality report on the results of the WHO/UNEP programme on health – related environmental monitoring.*

14. *WHO. 1982. Examination of water for pollution control, a reference hand book" vol. no- 1, 2.*