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EFFECT OF LAND USE ON WATER QUALITY OF THE TURAG RIVER

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ABSTRACT

Considerable research has been carried out to establish relationship between land use patterns and water quality in developed countries. In Bangladesh, research has been conducted in waste effluent effects on water quality with the surrounding environment. But very few research works have been done concerning land use effects on water sources though limited control on land use pattern makes river water more vulnerable to use. The purpose of this study is to identify water quality of the Turag River coming from residential/ industrial/ agricultural areas and to determine the impact of land use on water quality. As northern part of Dhaka city consists of a number of industries, Turag River is the water body receiving most of the agricultural, urban, industrial wastes. In the study, forty-five water samples in three different river depths were collected from five different points of the river based on the type of land use. Water samples were collected in the winter season to show a worse scenario. In laboratory, five basic water quality parameters- pH, Colour, Turbidity, Total Dissolved Solid, and Biochemical Oxygen Demand -were considered. A generalized survey was conducted around the sample collection sites to get a clear conception about the land use. The findings of the study show that only few of the test results are fitting in the existing standards. Besides Industrial pollutions, municipal point source of pollution had a great effect on the water quality. Quality of water deteriorates with the increase of land use.

Keywords: *Water Quality, Land Use, Turag River*

1 INTRODUCTION

Water is the most inevitable natural requisite to sustain life for plants and animals as well as human beings (Nwankwoala & Nwagbogwu, 2012). Water quality is important as a health and development issue at a national, religion and local level. Despite its necessity, water pollution is most crucial issue of the present world (Fakayode, 2005). For reducing water pollution, it is considered as the first priority to save fresh water resources from the pollutants. To accomplish this purpose, water quality testing is an essential part of environmental monitoring. These test basically includes Biochemical Oxygen Demand (BOD), Chemical oxygen demand (COD), E.coli test, TDS, Turbidity, Odor, pH, Iron concentration of water and Hardness of water (Tariquzzaman et al., 2016). Poor water quality affects not only aquatic life but also the surrounding ecosystem.

Land use has been considered not only as a local environmental issue, but also as a force of global importance (Foley et al. 2005). The need for providing food, fiber, water, and shelter to more than six billion people changes the conditions of forests, farmlands, waterways, and air. Global croplands, pastures, plantations, and urban areas have expanded with losses of biodiversity.

Since the late of 1970s, the influence of land use on water quality has been a major concern (Lee et al, 2009; Tran et al., 2010; Rothwell et al., 2010). Researchers started to analyze the correlation between land use and water quality mostly after the 90s (Johnson et al., 1997). Water quality assessment techniques was introduced to make these studies much convenient than before (Griffith, 2002; Ierodiaconou et al., 2005; Rothwell et al., 2010). The relationship between land use patterns and water quality explains the variations of river water quality in a water resource conservation and ecosystem management (Woli et al., 2004; Li et al., 2009). Besides, considerable water pollution is caused by various kinds of land use and practices such as rapid urbanization, growth of population, industrial and agricultural activities (Ngoye & Machiwa, 2004). Generally, agricultural land use has identified a strong command on the nutrient parameters in river water (Pieterse et al., 2003; Ngoye & Machiwa, 2004; Woli et al., 2004). Furthermore, industrial and urban land uses are associated with organic pollution, nutrients and heavy metals and other pollutants in the river water (Ferrier et al., 2001; Li et al., 2009).

In Bangladesh, Pasha et al. (2012) performed a study to assess the water quality of the Turag River situated at Gazipur and to identify the impact of industrial and domestic wastes on water quality. Domestic wastes have a significant effect on water quality associated with surrounding sanitation system. Islam et al. (2012) investigated solid waste and industrial effluents effect on water quality of the Turag River. The results of the study showed that the upstream water was neutral with comparatively high dissolved oxygen, but low values of other parameters. Besides that, solid wastes and industrial effluents being discharged into the river have considerable negative effects on the water quality of the river water and as such, the water was not good for human purposes and for other uses. So, a deep understanding is required concerning the relationship between land use effects and water quality in developing countries like Bangladesh. The purpose of this study is to identify water quality of the Turag River coming from residential/ industrial/ agricultural areas and to determine the impact of land use on water quality. The specific objectives are assessment of the present water quality of the Turag River in various points, comparison of various water quality parameters of the Turag River with the existing standards and finally studying the impact of various types of waste- domestic, industrial and agricultural- on the water quality of the Turag River.

2. STUDY AREA AND METHODOLOGY

Overall Study Area and Methodology involves selection of suitable water sample collection sites (Section 2.1), water quality parameter selection (Section 2.2), Sampling and analysis of Turag River water (Section 2.3), Survey data collection and analysis (Section 2.4) to find out the relationship between land use and water quality of Turag River.

2.1 Study Area

Dhaka is the most densely populated cities of Bangladesh having population of more than 15 million. Northern side of the city consists of numerous industries located in Tongi. As Turag River flows marking the edge of the city, water body of the river receives most of the agricultural, urban and industrial wastes. Over the last few decades, the river has undergone tremendous chemical and biological changes as a result of increasing human interferences. For the execution of the research, ten sites were primarily chosen from maps based on the probable dumping zone of domestic and industrial waste. After three rounds of reconnaissance, five sites (Table 1 & Figure 1) were finally selected based on odour and visible properties of water of the Turag River. Tongi Bridge was the base point of the research area.

Table 1: Location of the Sites of Turag River

Site No.	Name of the Location	Longitude	Latitude
A	Nagda Bridge, Pubail	23.917112	90.467734
B	Tongi Bridge, Tongi	23.882053	90.404182
C	Gudara Ghat, Tongi	23.897993	90.385506

D	Diabari, Uttara	23.883274	90.357300
E	Rustompur Bridge, Savar	23.878545	90.352000

Figure 1: Location of the Sites

2.2 Water Quality Parameters

Five water quality parameters were selected based on the testing apparatus availability and environmental importance for measuring sampling water quality.

2.2.1 pH

pH is a measure of the acidic or alkaline condition of water. It may be expressed as the hydrogen ion concentration, or more precisely the hydrogen ion activity. A controlled value of pH is desired in water supplies (coagulation, disinfection, water softening and corrosion control), sewage treatment and chemical process plants. For the Study, HACK pH meter was used. The pH scale ranges from 0 to 14. A pH value of 7 is neutral, less than 7 is acidic and greater than 7 is basic.

2.2.2 Turbidity

Turbidity is a measure of water clarity. A turbidity test will measure the decrease in the passage of light through a water sample based on the amount of floating materials in the water. Turbidity is caused by suspended materials which absorb and scatter light. Turbidity is a useful indicator of water quality changes. HANNA turbidity meter was used in the research to find the parameter.

2.2.3 Colour

Water is coloured to some extent due to the presence of various impurities i.e., iron and manganese in association with organic matter from decaying vegetation. Apparent colour is seen in the presence of suspended matter, whereas true colour is derived only from dissolved inorganic and organic matters. To measure this parameter, HACH Spectrophotometer was used for the study.

2.2.4 Total Dissolved Solid (TDS)

Total Solids (TS) are the total of all solids in a water sample. They include the Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). Total Suspended Solids (TSS) is the amount of solids in a water sample retained by a filter. Total Dissolved Solids (TDS) are those solids that pass through a filter with a pore size of 2.0 micron or smaller. They are said to be non-filterable. After filtration, the filtrate (liquid) is dried and the remaining residue is weighed and calculated as mg/L of Total Dissolved Solids.

Total solids measurement can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activities, sewage treatment plant discharges and other sources. The most important aspect of TDS with respect to drinking water quality is its effect on taste. The palatability of drinking water with a TDS level less than 600 mg/L is generally considered to be good. Drinking water supplies with TDS levels greater than 1200 mg/L are unpalatable to most consumers.

2.2.5 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) determination is a chemical procedure for determining the amount of dissolved organic matter to occur under standard condition at a standardized time and temperature. Usually, the time is taken as 5 days and the temperature is 20^0C. This is important parameter to assess the pollution of surface waters and ground waters where contamination occurred due to disposal of domestic of domestic and industrial effluents. Drinking water usually has a BOD of less than 1 mg/L. But, when BOD value reaches 5 mg/L, the water is doubtful in purity. HACH BODTrak was used in the study.

2.3 Sampling and Analysis of Water Sample

Almost 80% of the annual average rainfall of 1854 millimeters (73.0 in) occurs during the monsoon season which lasts from May till the end of September. So the pollutants get diluted during rainy season. So water samples were being collected in the winter season (January-March) to show a worse scenario than that for the rainy season. In the study, 45 water samples of different river depths (1.5, 3, 4.5 feet) were collected from five different points of the Turag River. Different river depths are to investigate the water quality changes. In laboratory, five basic water quality parameters- pH, Colour, Turbidity, Total Dissolved Solid, and Biochemical Oxygen Demand -were measured for each water sample. Finally, the values were compared with existing water quality standard to find out the water quality of the Turag River.

2.4 Survey Data Collection and Relationship with Water Quality

A survey was conducted near the selected five points to get some hand to hand data on the land uses around the selected points. Types of waste- agricultural, industrial, domestic- generated in the surrounding points, Type of land use which generates the wastes were the main concern of the survey. The survey wants to focus on how water quality changes with land use. The main causes of the site wastes were also identified. Finally, the relationship between water quality and land use was developed.

3. ANALYSIS AND RESULTS

The results obtained following the outlined methodology are organized into three sub-sections of which Section 3.1 is water sample data analysis and comparing with existing drinking water quality standard for Bangladesh, Section 3.2 is summarizing the survey data and Section 3.3 is to identify the relationship between water quality and land use of the Turag River.

3.1 Water Sample Data Analysis and Existing Water Standard

Table 2 illustrates water quality parameter data- pH, Turbidity in FTU, Colour in Pt/Co, TDS in mg/L, BOD_5 in mg/L- in three different depths (1.5 feet, 3 feet, 4.5 feet) for five selected locations (Section 2.1) of Turag River. Figure 2 shows the average water parameter values for each depth and site as three water sample was collected for each section.

Table 2: Water Quality Parameters Data for Turag River

Site	Depth in feet	Sample No	pH	Turbidity (FTU)	Colour (Pt/Co)	TDS (mg/L)	BOD_5 (mg/L)
A	1.5	AD1_01	7.66	112	496	1150	23
		AD1_02	7.66	112	496	1150.5	23
		AD1_03	7.67	110	496	1149.3	23
	3	AD2_01	7.67	108	492	1147.4	22
		AD2_02	7.68	107	491	1147	21
		AD2_03	7.68	107.1	492	1147.4	21
	4.5	AD3_01	7.7	105	488	1145.9	20
		AD3_02	7.7	106.3	488	1146	21
		AD3_03	7.7	106	487	1146.7	20
B	1.5	BD1_01	7.49	110	403	872.5	24
		BD1_02	7.51	109	402	872	22
		BD1_03	7.5	106	402	871.9	24
	3	BD2_01	7.52	103.2	400	870	23
		BD2_02	7.53	103	401	870	23
		BD2_03	7.52	104	400	871.1	23
	4.5	BD3_01	7.53	100.7	395	871	21
		BD3_02	7.53	100	396	869.5	21
		BD3_03	7.53	100	395	869.4	20
C	1.5	CD1_01	7.91	97	251	1600	31
		CD1_02	7.92	97	250	1600.2	30
		CD1_03	7.91	98.9	250	1601	30
	3	CD2_01	7.94	94.1	250	1597	30
		CD2_02	7.93	92.8	250	1598	29
		CD2_03	7.93	92	249	1596	28
	4.5	CD3_01	7.93	90	247	1596	27
		CD3_02	7.95	90.5	247	1596.8	27
		CD3_03	7.95	90.6	246	1595.3	28
D	1.5	DD1_01	7.04	41.3	324	629	19
		DD1_02	7.04	40.9	324	628.6	18
		DD1_03	7.04	41.1	325	628	18
	3	DD2_01	7.07	40.6	323	628	16
		DD2_02	7.08	39.9	321	627.1	15
		DD2_03	7.07	40	321	627.7	16
	4.5	DD3_01	7.1	39.2	321	626	14
		DD3_02	7.11	39.7	320	626	15
		DD3_03	7.11	38.6	319	626.9	15

E	1.5	ED1_01	7.1	33.7	387	746	17
		ED1_02	7.1	33.7	385	745	18
		ED1_03	7.12	32.9	387	745.9	17
	3	ED2_01	7.15	30.5	385	745	18
		ED2_02	7.15	30.6	382	744	18
		ED2_03	7.16	30	384	744.8	17
	4.5	ED3_01	7.17	28.9	381	744	15
		ED3_02	7.17	28	381	743	16
		ED3_03	7.18	28.6	380	743.2	16

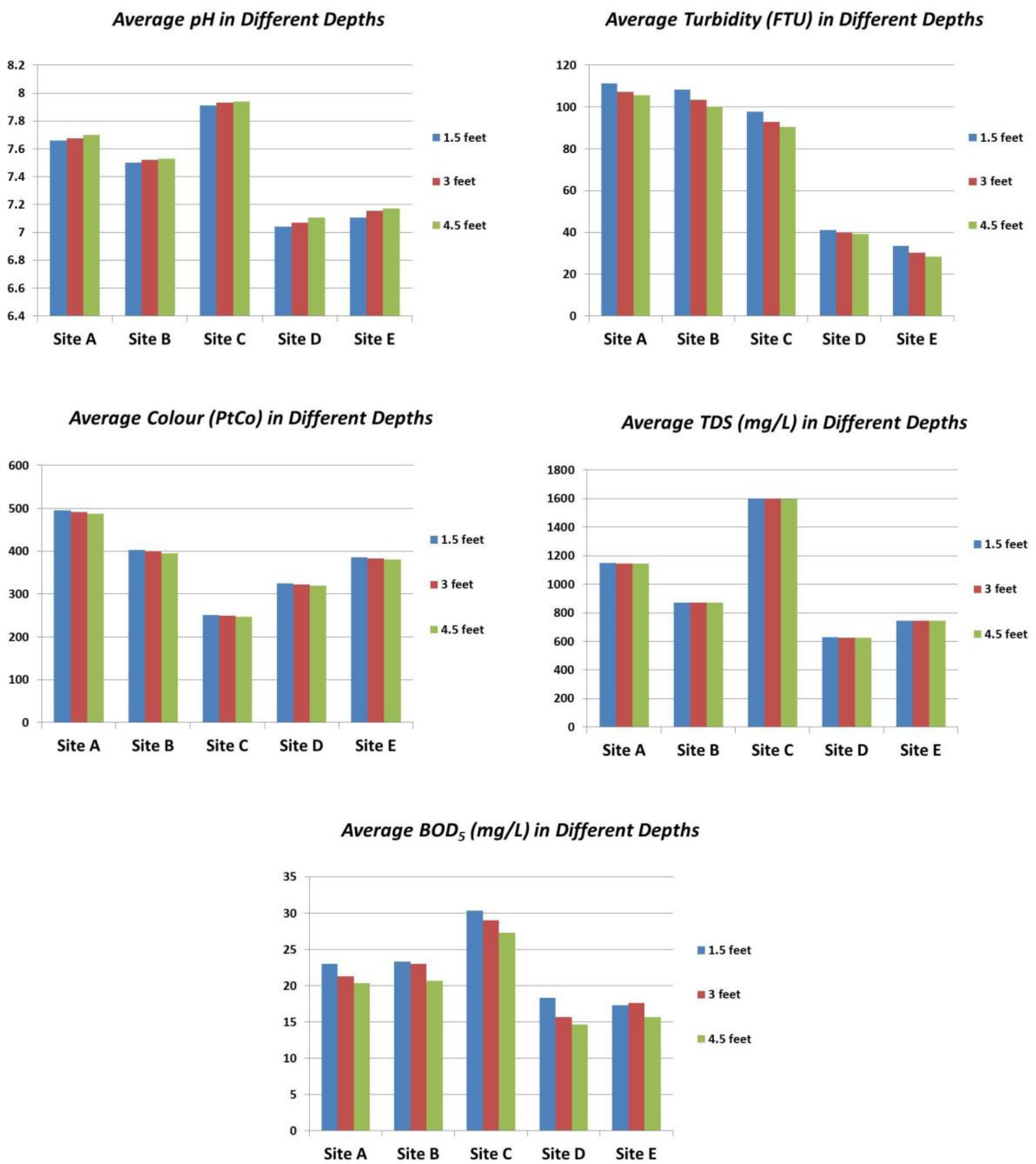

Figure 2: Average Water Quality Parameters Data

Average pH values range for Site-A in depths was in between 7.65 to 7.7 which is slightly alkaline (>7). Besides, Turbidity and Colour average values in all depths were considerably higher than existing drinking water standard (Table 3). Higher colour value means water in yellowish colour. Turbidity is related to suspended matter of water and therefore high turbidity values (1149.93, 1147.26, 1146.2 mg/L) of Site-A demonstrate high number of suspended particles in Turag water. As BOD levels are high (23, 21.33, and 20.33), Dissolved Oxygen (DO) levels decrease because available oxygen in water is being consumed by the bacteria.

Table 3: Drinking Water Quality Existing Standard in Bangladesh (Source: ECR)

Experiment Name	Standard for Drinking Water	Standards for inland surface water
pH	6.5-8.5	6.5-8.5
Turbidity (FTU)	10	--
Colour (Pt/Co)	15	--
TDS (mg/L)	1000	--
BOD_5 (mg/L)	0.2	6

Site-B had pH values slightly higher than neutral level (7.0). Turbidity and Colour test values were mostly similar to Site-A. Though Turbidity and pH values of this site were within standard limit (<1000 mg/L and 6.5 to 8.5), other water quality measurement like BOD, Colour, TDS obtained much higher values than expected. Thus, Site-B river water is not suitable for drinking and recreational activities. Site C showed slightly higher pH values (7.91, 7.93, and 7.94) than other sites. Total Dissolved Solids (TDS) is mainly related to the presence of numerous kinds of minerals like ammonia, nitrite, nitrate, phosphate, alkalis, sulphates and metallic ions which consist of both colloidal and dissolved solids in water. Therefore, higher TDS value in Site-C (>1500 mg/L) indicates the presence of minerals in river water. Since TDS value was the highest, BOD achieved higher value in the Site-C than other sites.

Site-D showed low BOD values (18.33, 15.66, and 14.66) as TDS represented much lower values than Site-C. Besides, turbidity value is considerably lower than other zones but not low enough to satisfy water standard limit. Consequently, pH values were close to neutral (7.04, 7.07, and 7.1). Site-E water exhibited similar water condition to Site-D as pH values were slightly higher and other parameter values are mostly parallel.

Changes in water quality have been found in different depths. Water quality in 3 feet below from river water level is slightly better than 1.5 feet. Similar pattern has been also applicable for depth 4.5 feet. For proper demonstration, water needs to collected from as higher river depths as possible. Therefore, from Table-2, water quality may increase with collected river water depths.

3.2 Summarizing Survey Data

Generalized Survey was conducted to identify major purposes of land use on the selected five sites. Land use is related to the surrounding environment, benefits and social economic condition. In the study, type of waste in river water depends on surrounding environment and land use.

Site-A waste is mainly agricultural. The area around site A is in under cultivation of rice mainly. Approximately 500000 m^2 area is under cultivation for only four months. 10-20 kilograms of fertilizer is used in 3643 m^2 land thrice in cultivation time. In total for cultivation, around 6 tons of fertilizers are used. The main ingredients of these fertilizers are Nitrogen (N), Potassium (K), Zinc (Zn) and Gypsum ($CaSO4.2H2O$). Though Potassium (K) is applied, its quantity is very less.

Markets cover at 180000 m^2 area at Site-B. Waste produced in the market is dumped in the Turag River. Waste is mostly industrial and domestic (organic).

There are at least two markets, one hospital, two steel/ aluminum mills, one pharmaceutical company in Site-C which contribute in the waste dumped in the Turag River. Around 5,000 m^3 domestic wastes are dumped. Besides, eight vans, each approximately of 1.7344069 m^3 volume, dump waste at Site-C all the year round. Values of environmental parameters at site of Gudara Ghat has topped in most of the experiment due to the type of waste present there as well as the waste brought by the stream. A university, a hospital, and two big and several other small slums, various kinds of industries are situated in the adjacent area of Turag between Tongi Bridge (Site-B) and Gudara Ghat (Site-C).

Site-D and Site-E mainly contain the flow from upstream which combines with another flow of the Turag River. A very small area is cultivated only in the dry season which remains under water for the most part of the year. The waste dumped at Diabari (Site-D) and Rustompur Bridge (Site-E) is mainly industrial. In addition, Site-E has a market covering a small area of the site. Table 4 illustrates the major type of wastes that are dumped in Turag River.

Table 4: Major Waste Type in Sites

Site	Types of Water Use					
	Agricultural	**Market**	**Industrial**	**Household**	**Hospital**	**Institution**
A	✓					
B		✓	✓	✓		
C	✓		✓	✓	✓	✓
D	✓		✓			
E	✓	✓	✓			

3.3 Relationship between Land Use and Water Quality of Turag River

The main purpose of purpose of the study is to find out the relationship between land use and water quality. Water quality of five different sites on the Turag River in different depths was tremendously poor (Section 3.1). Due to urbanization, numerous type of waste has been dumped on the river (Section 3.2).

Site-A mainly contains agricultural waste. Due to various kinds of fertilizer use, water of Site-A obtains high pH, TDS and Turbidity values. Increased sediment loads create more suspended particles that increase turbidity level. Factors affecting the phytoplankton distribution are water temperature, TDS, alkalinity and dissolved oxygen. Runoff from agricultural land increase BOD level which can be harmful for aquatic animals. Different ingredients in fertilizer deteriorate colour of river water. Alongside agricultural waste, industrial and household wastes also contribute to the river water pollution. Domestic and industrial wastes in the Site-B deteriorate water quality by adding substances in water. Due to heavy metal concentration, Site-B average pH values were lower than Site-A. Effluents discharged without treatment in river are responsible for turbidity, colour, and TDS increment. Furthermore, anthropogenic impacts generated through domestic waste directly affect watershed hydrology and reduce water quality.

At Site-C, waste is mixture of agriculture, industrial, domestic and hospital. Thus water quality of Site-C was the worse. Due to water stream, turbidity value may be reduced but this does not mean improving water quality. High pH, TDS and BOD values illustrate increasing water pollution tendency (7.91, 1600, 30). The findings clearly indicate that water is polluted because of discharge of sewage and other anthropogenic activity. Diabari (Site-D) mostly carries agricultural and industrial wastes. Water at this site was less pH values than Site-A probably because of the acidic nature of the main ingredients of the fertilizers. The main noticeable point is that due to less waste, Site-D river water quality was slightly better than Site-C, Site-A and Site-B.

Site-E contains agricultural, market and industrial waste. Agricultural waste amount was less than Site-A and Site-C. Following this, Site-E water quality parameter values are less than those sites. Finally, findings of the study clearly suggest relationships between land use and water quality. Water quality decreases with increasing land use for different purposes.

4. CONCLUSION

The Turag River becomes a crucial resource to approximately two million people. The major concern is that only a few of the test results are fitting in the existing standards while the others are way off the chart. It is clear from the values from the test and observational survey results that the pollution is escalating rapidly day by day. Numerous industries and land uses developing along the banks of the Turag River cause more pollution and encroachment on river bank. Thus, it can be concluded that the water of this river may exhibit serious threat to the surrounding biological ecosystem. However, some water quality parameters may not be at critical pollution level, the condition of the river side due to urbanization and industrialization may cause severe pollutions. Land use which is a major variable of development of the socio-economic condition, is taking its toll on the water quality of Turag in case of Gazipur. Quality of water deteriorates with the increase and density of land use. In the meantime, the pollution level of the Turag has not yet gone above treatability and the river has not been under the massive grasp of encroachment. Therefore, recovery process of the river needs to be started immediately. Local organizations, residents and provincial, federal departments all should involve in the restoration of the River ecosystem. Discharge of industrial effluents near the surface water as well as domestic waste from residential areas should be decreased and establishment of sewage treatment plants is needed to monitor the region human settlements. A further recommendation is the organization of educational programs to provide proper information to people in the local area about waste water management and soil conservation methods. Some work has already begun in these areas, especially in terms of wastewater management, but much work is required to encourage the use of land management practices in the areas.

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