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Full Length Research Paper

Assessment of water quality and impact of effluents from fertilizer factories to the Lakhya River

Mohammad Hafizul Islam[1]*, Md. Mafizur Rahman[2] and Fahmidah Ummul Ashraf[3]

[1]Public Works Department, Sub-Divisional Engineer, Bangladesh.
[2]Department of Civil Engineering, BUET, Bangladesh.
[3]Water Resources Engineering, BUET, Bangladesh.

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A study was carried out in Polash and Ghorasal Urea fertilizer factories to assess the impact of effluent on water quality of the Lakhya River. Comprehensive waste water sampling by grab sampling method and flow measurement by float velocity method were carried out for five weeks (one sample per week) at five sampling stations at Polash and Ghorasal Urea fertilizer factories during June to July, 2007. Water quality samplings by grab sampling method were also carried out for five weeks (one sample per week) at four stations in the Lakhya River at the same time and River flows on the period of October 2006 to September 2007 were collected from Institute of Water Modelling. Effluents at both the factories and water sample from selected points in the river were analysed for pH, temperature, DO, BOD_5, COD, NH_3-N, NH_4-N, TS, TSS, and TDS during June to July, 2007 at the Environmental Engineering Laboratory of Bangladesh University of Engineering and Technology, Bangladesh. The results showed that the effluents were alkaline while the level of DO, BOD_5, COD, NH_3-N, NH_4-N, TS, TSS, and TDS relatively high and 17425-20012 kg/day Ammonia load discharged from fertilizer factories into the Lakhya River. The upstream water was near to neutral pH (average pH, 7.66 ± 0.102) with high dissolved oxygen but low in the levels of the other parameters. The river water after the effluent receiving points was basic (average pH, 8.16 ± 0.08) and the levels of other parameters were high due to heavy pollution load especially Ammonia discharged from fertilizer factories. The results suggested that water in the river was polluted and not good for human consumption. It is therefore recommended that the disposal of improperly treated or untreated wastes should be stopped to save the river water from further deterioration.

Key words: Industrial effluents, Impact, river water, pollution, water quality.

INTRODUCTION

Water is essential to all forms of life and makes up 50 to 97% of the weight of all plants and animals and about 70% of human body (Buchholz, 1998). Water is also indispensable for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world (Fakayode, 2005). Ground and surface waters can be contaminated by several sources. In farming areas, the routine application of agricultural fertilizers is the major source of contamination (Altman and Parizek, 1995; Emongor et al., 2005). In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the contamination and poor quality of the water (Chindah et al., 2004; Emongor et al., 2005; Furtado et al., 1998 and Ugochukwu, 2004). A study on the impact of industrial effluent on water quality of a river carried out in Nigeria (Fakayode, 2005) showed that the chemical parameters studied were above the allowable limits and also tended to accumulate downstream. Most of the rivers in the urban areas of the developing world are the end points of effluents discharged from the industries. Industrial effluents, if not treated and properly controlled can also pollute ground water (Olayinka, 2004). Therefore, both bore holes and rivers generally have poor quality

* Corresponding author. E-mail: hafizbuet@gmail.com.

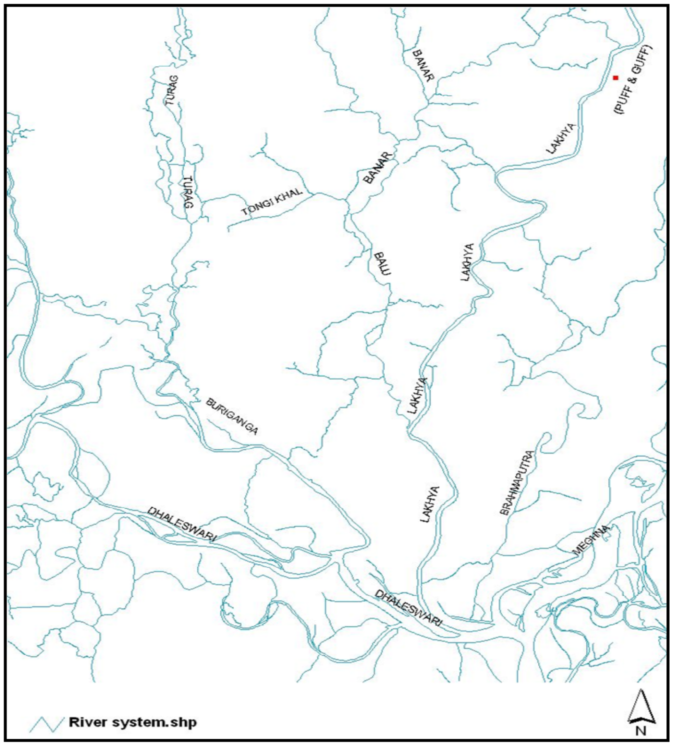

Figure 1. Location of fertilizer factories and perepheral river system around Dhaka City.

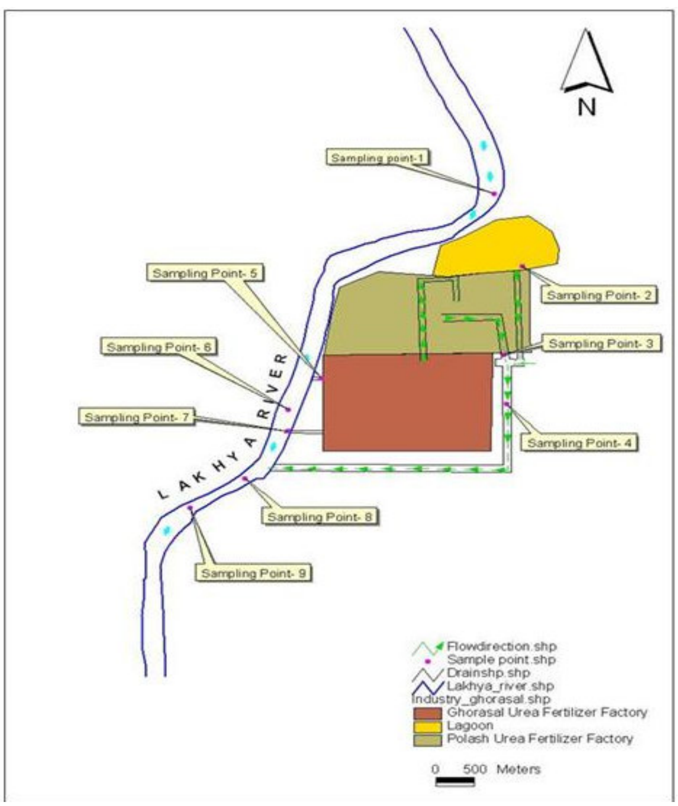

Figure 2. Sample and sampling.

water in the affected areas. Bangladesh is experiencing rapid industrial growth and this is making environmental conservation a difficult task (WB, 2007).

In Dhaka, the capital city of Bangladesh, there are a number of rivers that run through several industrial sites carrying large amount of discharged industrial effluents (Figure 1). People living in the river side use such contaminated water for domestic purposes. Unfortunately, there is no enough information about the quality of the effluent discharged into this river and also about the quality of the river water which is standard for human use.In this circumstances it is difficult for the authorities to take proper action in preventing pollution of water environment which is essential for surrounding living communities and Global Environment. The objective of this study was therefore to assess the extent of chemical pollution of the Lakhya river as it is increasingly polluted by industrial effluents.

MATERIALS AND METHODS

Study area

The study was conducted in the effluent channels from two industries and in the Lakhya River that runs through an industrial area in Dhaka, the capital city of Bangladesh. Water and wastewater sampling, flow measurement points are shown in Figure 2. The industries which discharge effluents into the Lakhya River are the Polash and Ghorasal urea fertilizer factories.

Sample and sampling

Samples of effluents and discharge data were collected for five weeks (one sample per week) at sampling points-2,3,4,5 and 7. Water samples in the river were also collected for five weeks (one sample per weeks) at sampling points-1,6,8 and 9. Discharge of river were collected from secondary sources. Sampling point-1: This point is located upstream of the fertilizer factories. Water sample collected from this point was unaffected by the effluent of the fertilizer factories (Polash and Ghorasal). Sampling point-2: This is the lagoon where effluent discharged from the fertilizer factories (Polash and Ghorasal) was retained. This point was very close to the pump. Ultimately this effluent was discharged into the Lakhya River through pump without treatment. Sampling point-3: This is the channel of the Polash urea fertilizer factory. The treated effluent of this factory was discharged through this channel. The performance of the treatment process of Polash urea fertilizer factory was evaluated from this point. Sampling point-4 is located in a channel where the discharged effluent was the combination of treated effluent discharged from the Polash urea fertilizer factory and untreated effluent discharged from Lagoon. This channel discharged effluent into the Lakhya River. Sampling point-5: Untreated effluent of Ghorasal urea fertilizer factory was discharged through this point. Sampling point-6: This point is 1000 m downstream from the sampling point-1. The water samples at this point were affected by the untreated effluent of Ghorasal urea fertilizer factory. Sampling point-7: This point is on the channel of the Ghorasal urea fertilizer factory. The treated effluent of this factory was discharged through this channel. This channel discharged effluent into the Lakhya River. The performance of the treatment process of Ghorasal urea fertilizer factory was evaluated from this point. Sampling point-8: This point is 538 m downstream from the sampling point-6. The water samples of this point were totally affected by both the fertilizer factories (Polash and Ghorasal). Combined effects of effluent from both the factories on the Lakhya were evaluated from the investigation at this point. Sampling point-9: This point is 514 m downstream from the sampling point-8. The water samples of this point were also totally affected by both the fertilizer factories (Polash and Ghorasal). This point was necessary to evaluate the impact of effluent from fertilizer factories along the length of the river. All samples were placed into thoroughly cleaned 1 liter polyethylene bottles and tightly closed. Each bottle was rinsed with the appropriate sample before the final sample collection. The samples were placed in a cooler box and then taken to the Environmental Engineering Laboratory, Bangladesh University of Engineering and Technology for analysis. Samples were carried out in the June to July, 2007.

Chemical analysis

pH, Temperature, DO: The parameters were analysed by electronic method by using pH meter (Hach), Temperature meter and DO meter respectively.
BOD_5: The parameter were analysed by using standard method for analysis of water and waste water, 20th Edition, APHA, AWWA, WEE, 1998 COD (Dichromate value): The parameter was analysed by Reactor Digestion Method by using Spectrophoto meter (Hach DR/4000U) .
NH_3-N, NH_4-N : The parameters were analysed by Nessler Method by using Spectrophoto meter (Hach DR/4000U).
TS, TSS, TDS : The parameters were analysed by Standard Method 2540C by using Oven (Despatch Co.USA) (Standard methods for Analysis of water and wastewater, 20^{t}h Edition, APHA, AWWA, WEE, 1998)

RESULTS

Analysis of water quality along the Lakhya River to assess the impact of effluent from Polash and Ghorasal urea fertilizer factories

Biochemical oxygen demand (BOD)

The level of BOD_5 (Figure 3) was 8 to11 mg/l (9.2 ± 1.16 mg/l) in the sampling point-1. In the sampling point-6 it was 9 to 11 mg/l (10 ± 0.89 mg/l) in which 146.97 to 348.19 kg/day (226.18 ± 66.26 kg/day) BOD_5 discharged from sampling point-5. In the sampling point-8, it was 11 to 14 mg/l (12.4 ± 1.01 mg/l) in which 2518.3 to 3094.42 kg/day (2902.92 ± 211.31 kg/day) BOD_5 discharged from sampling point-4 and 7. For the dilution factor the BOD_5 reduced in the sampling point-9 and it was 10 to 13 mg/l (11.4 ± 1.01 mg/l).

Chemical oxygen demand (COD)

The level of COD (Figure 4) was 12 to 19 mg/l (15.8 ± 2.78 mg/l) in the sampling point-1. In the sampling point-6 it was 15 to 21 mg/l (18 ± 2.52 mg/l) in which 258.94 to 595.29 kg/day (369.49 ± 118.68 kg/day) COD discharged from sampling point-5. In the sampling point-8 it was 18 to 23 mg/l (20.6 ± 2.24 mg/l) in which 4455.64 to 4644.45 kg/day (4543.72 ± 67.82 kg/day) COD discharged from sampling point-4 and 7. For the dilution factor the COD reduced in the sampling point-9 and it was 17 to 22 mg/l (19.6 ± 2.24 mg/l).

Dissolved oxygen (DO)

The level of DO (Figure 5) was 4 to 4.8 mg/l (4.476 ± 0.26 mg/l) in the sampling point-1. In the sampling point-6 it was 3.9 to 4.4 mg/l (4.08 ± 0.19 mg/l) due to pollution load discharged from sampling point-5. In the sampling point-8 it was 3.78 to 4.1 mg/l (3.9 ± 0.12 mg/l) due to pollution load discharged from sampling point-4 and 7. For the dilution factor pollution load reduced, so DO increased in the sampling point-9 and it was 3.81 to 4.2 mg/l (3.948 ± 0.14 mg/l).

pH

The level of pH (Figure 6) was 7.5 to 7.8 (7.66 ± 0.102) in the sampling point-1. In the sampling point-6 it was 7.9 to 8.3 (8.1 ± 0.12) due to pollution load discharge from sampling point-5. In the sampling point-8 it was 8 to 8.4 (8.18 ± 0.13) due to pollution load discharge from sampling point-4 and 7. For the dilution factor pollution load decreased at the sampling point-9, so pH decreased at that point and it was 8.1-8.3 (8.16±0.08).

Temperature

The level of temperature (Figure 7) was 28 to 31.4℃ (29.68 ± 1.13℃) in the sampling point-1. In the sampling point-6 it was 28 to 32℃ (30.4 ± 1.43℃) due to pollution load in high temperature discharged from sampling point-5. In the sampling point-8 it was 28.2 to 31.7℃ (30.14 ± 1.26℃) due to pollution load in high temperature discharged from sampling point-4 and 7. In the sampling point-9, it was 28.1 to 30.5℃ (29.72 ± 1.04℃).

Total ammonia (NH_3-N + NH_4-N)

The concentration of total ammonia (Figure 8) was 0.685 to 0.71 mg/l (0.69 ± 0.009 mg/l) in the sampling point-1. In the sampling point-6 it was 0.97 to 1.19 mg/l (1.086 ± 0.079 mg/l) due to 7368 to 11203 kg/day (8624 ± 1344 kg/day) total ammonia discharged from sampling point-5. In the sampling point-8, it was 1.09 to 1.30 mg/l (1.2 ± 0.072 mg/l) due to 8808-10467 kg/day (9577 ± 533 kg/day) total ammonia discharged from sampling point-4 and 7. For the dilution factor the total ammonia reduced in the sampling point-9 and it was 0.95 to 1.15 mg/l (1.05 ± 0.07 mg/l). It was observed that fertilizer factories are the major sources of total ammonia discharged into the Lakhya River in the

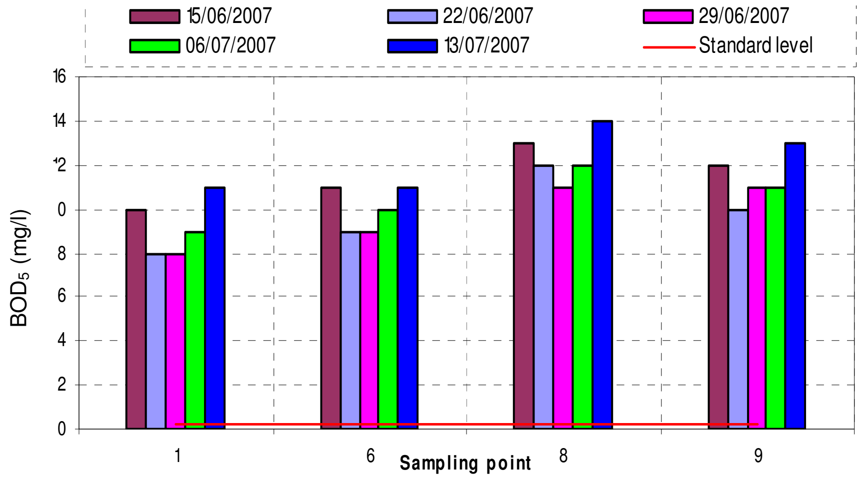

Figure 3. Variation of BOD_5 in mg/l along the Lakhya River.

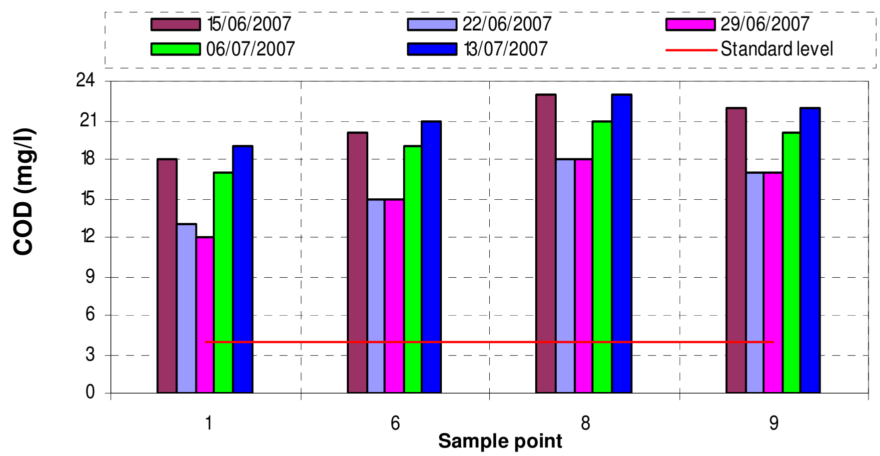

Figure 4. Variations of COD in mg/l along the Lakhya River.

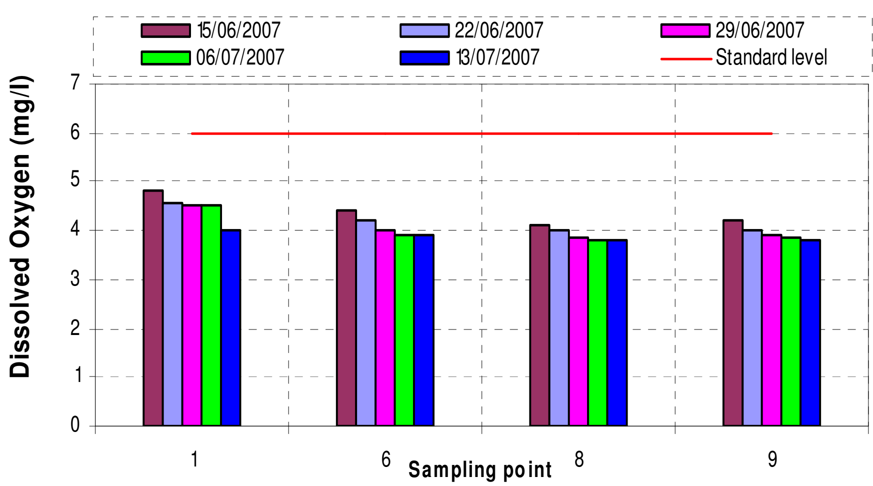

Figure 5. Variation of DO in mg/l along the Lakhya River.

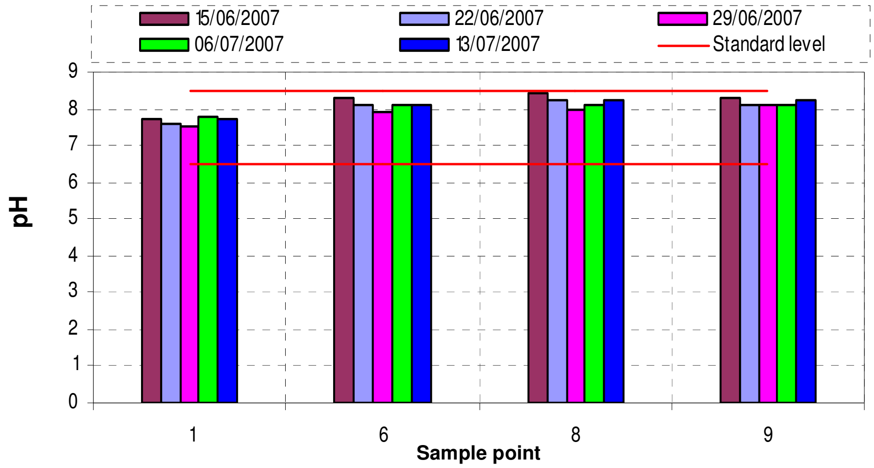

Figure 6. Variation of pH along the Lakhya River.

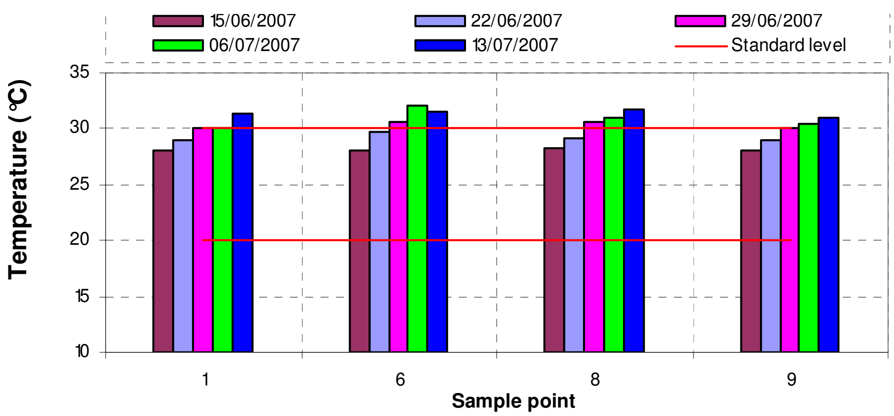

Figure 7. Variation of temperature in °C along the Lakhya River.

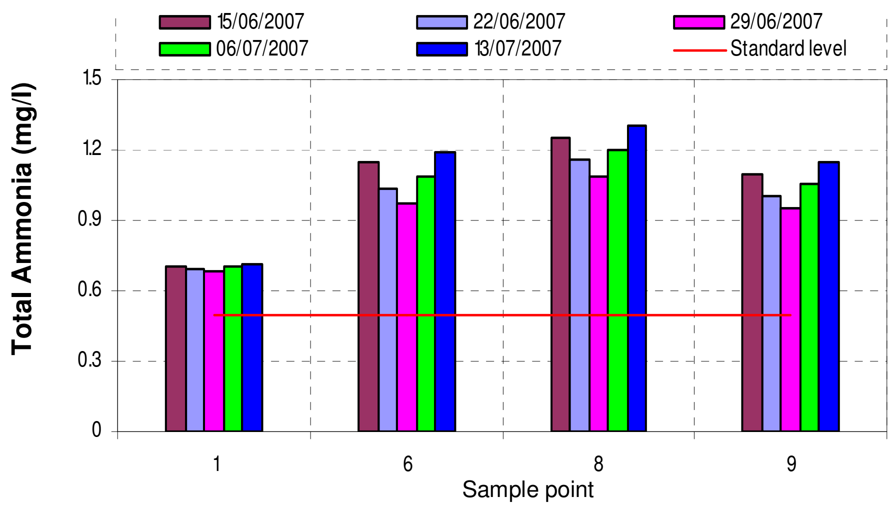

Figure 8. Variation of total Ammonia in mg/l along the Lakhya River.

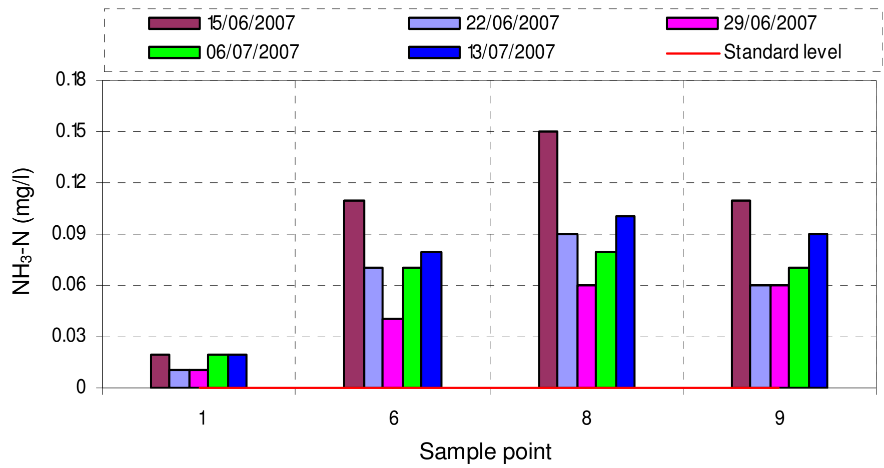

Figure 9. Variation of NH_3-N in mg/l along the Lakhya River.

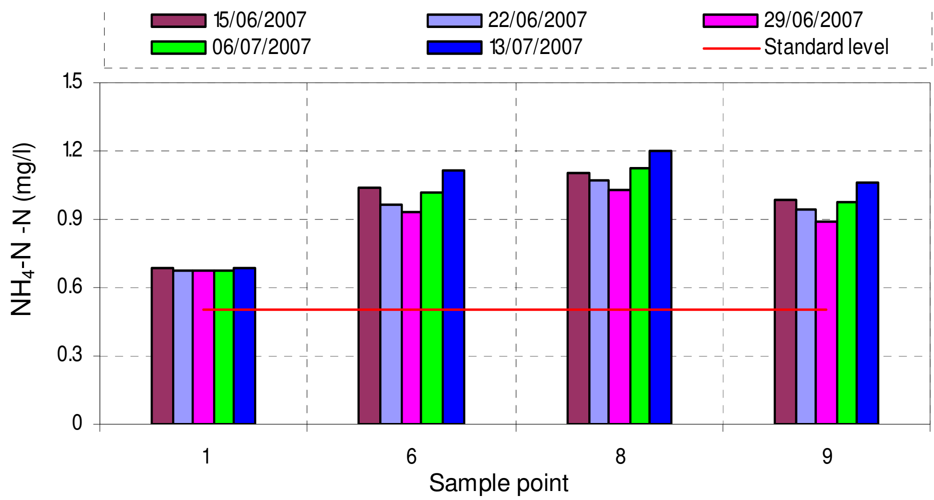

Figure 10. Variation of NH_4-N in mg/l along the Lakhya River.

study area. The concentration of total ammonia in the sampling point-9 is greater than the concentration of total ammonia in the sampling point-1. This increment was due to the ammonia load discharged from fertilizer factories. So the Ammonia load discharged from fertilizer factories has a large impact on water quality of the Lakhya River.

Ammonia as nitrogen (NH_3-N)

The concentration of Ammonia as Nitrogen (NH_3-N) (Figure 9) was 0.01 to 0.02 mg/l (0.016 ± 0.0004mg/l) in the sampling point-1. In the sampling point-6 it was 0.08-0.11 mg/l (0.074 ± 0.022 mg/l) due to 4975.23 to 6598.68 kg/day (5643.73 ± 590.45 kg/day) NH_3-N discharged from sampling point-5. In the sampling point-8 it was 0.06 to 0.15 mg/l (0.096 ± 0.03 mg/l) due to 2322.54 to 5265.65 kg/day (3542.03 ± 1080.86 kg/day) NH_3-N discharged from sampling point-4 and 7. For the dilution factor the NH_3-N reduced in the sampling point-9 and it was 0.06-0.11 mg/l (0.078 ± 0.01 mg/l). It was observed that fertilizer factories are the major sources of Ammonia (NH_3-N) discharged into the Lakhya River in the study area. The concentration of Ammonia in sampling point-9 is greater than the concentration of Ammonia in sampling point-1. This increment was due to the Ammonia discharged from fertilizer factories. So the Ammonia discharged from fertilizer factories has a large impact on water quality of the Lakhya River.

Ammonium as nitrogen (NH_4-N)

The concentration of Ammonium as Nitrogen (NH_4-N) (Figure 10) was 0.67 to 0.69 mg/l (0.68 ± 0.007 mg/l) in the sampling point-1. In the sampling point-6 it was 0.93 to

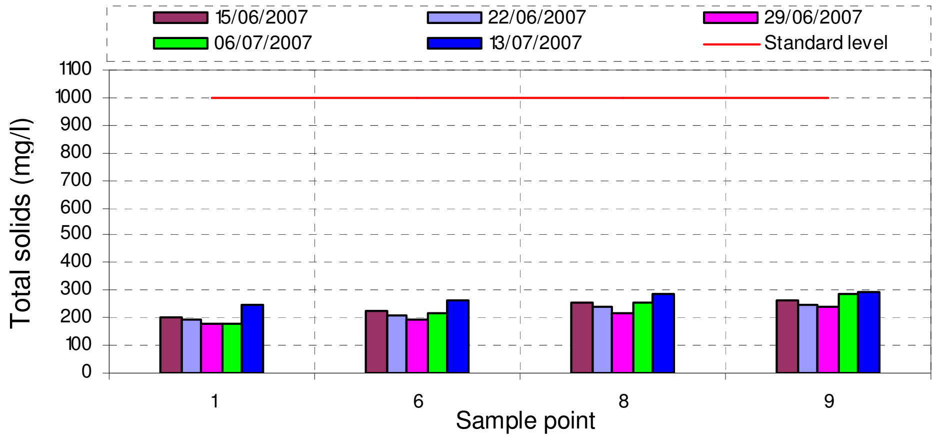

Figure 11. Variations of total solids in mg/l along the Lakhya River.

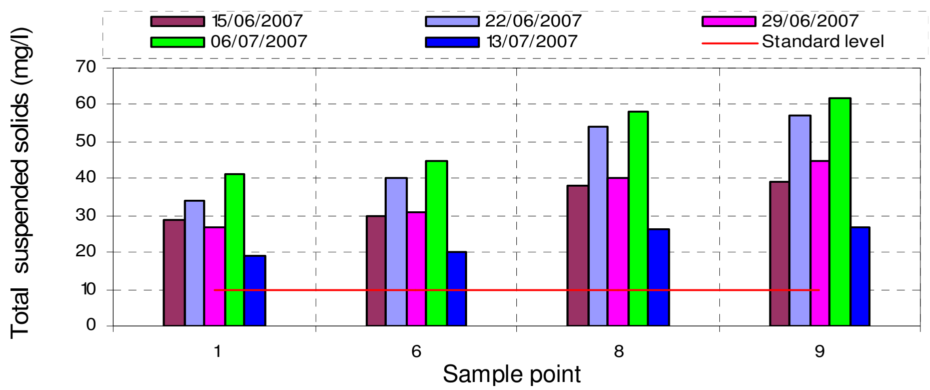

Figure 12. Variations of total suspended solids in mg/l along the Lakhya River.

1.11 mg/l (1.01 ± 0.06 mg/l) due to 1903.08 to 5988.22 kg/day (2980.78 ± 1541.86 kg/day) NH_4-N discharged from sampling point-5. In the sampling point-8 it was 1.03 to 1.20 mg/l (1.104 ± 0.05 mg/l) due to 5201.7 to 7064.64 kg/day (6035.72 ± 687.03 kg/day) NH_4-N discharged from sampling point-4 and 7. For the dilution factor the NH_4-N reduced in the sampling point-9 and it was 0.89-1.06 mg/l (0.97 ± 0.05 mg/l). It was observed that fertilizer factories are the major sources of Ammonium (NH_3-N) discharged into the Lakhya River in the study area. The concentration of Ammonium in sampling point-9 is greater than the concentration of Ammonium in sampling point-1. This increment was due to the Ammonium load discharged from fertilizer factories. So the Ammonium load discharged from fertilizer factories has a large impact on water quality of the Lakhya River.

Total solids (TS)

The concentration of TS (Figure 11) was 179 to 247 mg/l (200 ± 24.88 mg/l) in the sampling point-1. In the sampling point-6 it was 193-261 mg/l (220 ± 22.82 mg/l), in which 1523 to 3077 kg/day (1908 ± 594 kg/day) TS discharged from sampling point-5. In the sampling point-8 it was 220 to 286 mg/l (251 ± 21.6 mg/l) in which 5925 to 7302 kg/day (6816 ± 606.69 kg/day) TS discharged from sampling point-4 and 7. Total solids were accumulated in the downstream, for this, the value of TS were increased in the sampling point-9 and it were 237 to 298 mg/l (267.6 ± 22.08 mg/l).

Total suspended solids (TSS)

The concentration of TSS (Figure 12) was 19 to 41 mg/l (30 ± 7 mg/l) in the sampling point-1. In the sampling point-6 it was 20 to 45 mg/l (33.2 ± 8.65 mg/l) in which 1394 to 2623 kg/day (2060 ± 451 kg/day) TSS discharged from sampling point-5. In the sampling point-8 it was 26 to 58 mg/l (43.2 ± 11.56 mg/l) in which 118 to 752 kg/day (348 ± 213 kg/day) TSS discharged from sampling point-4 and 7. Total suspended solids were accumulated in the downstream, for this, the value of TSS were increased in the sampling point-9 and it were 27 to 62 mg/l (46 ± 12.55 mg/l).

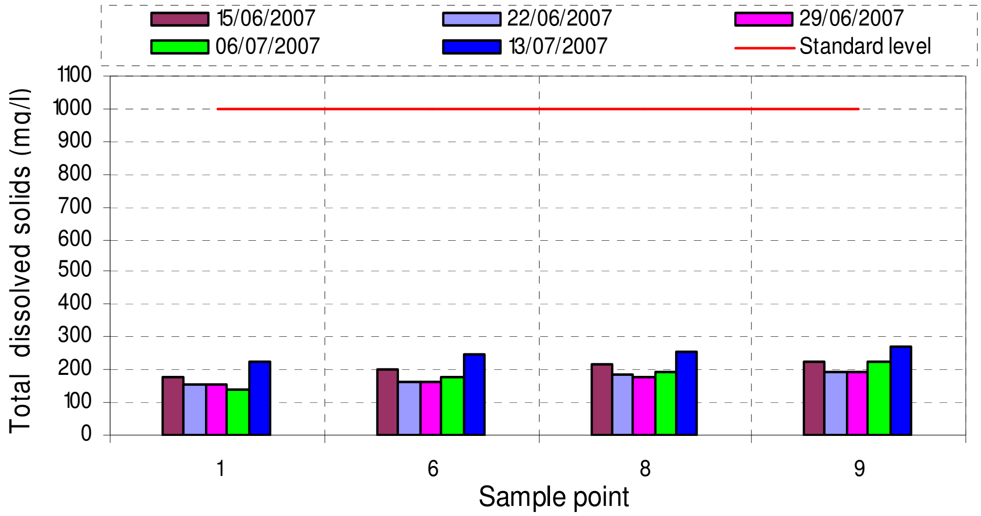

Figure 13. Variation of total dissolved solids in mg/l along the Lakhya River.

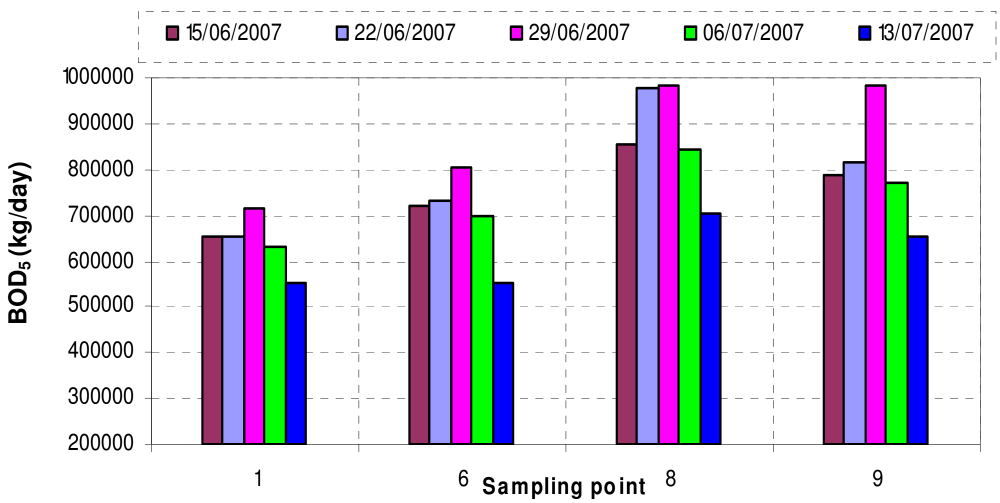

Figure 14. Variation of BOD_5 in kg/day along the Lakhya River.

Total dissolved solids (TDS)

The concentration of TDS (Figure 13) was 141 to 228 mg/l (170 ± 30 mg/l) in the sampling point-1. In the sampling point-6 it was 162 to 245 mg/l (190.2 ± 30.91 mg/l) in which 1394 to 2623 kg/day (2060 ± 451 kg/day) TDS discharged from sampling point-5. In the sampling point-8 it was 181 to 257 mg/l (207.4 ± 27.8 mg/l) in which 118 to 752 kg/day (348 ± 213 kg/day) TDS discharged from sampling point-4 and 7. Total suspended solids were accumulated in the downstream, for this, the value of TDS were increased in the sampling point-9 and it were 192 to 271 mg/l (221.6 ± 28.7 mg/l).

Analysis of pollution load along the Lakhya River to assess the impact of Polash and Ghorasal urea fertilizer factories effluent

Biochemical oxygen demand (BOD)

The amount of pollution load along the Lakhya River of BOD_5 (Figure 14) was 552878 to 713615 kg/day (640523 ± 51939 kg/day) in the sampling point-1. In the sampling point-6 it was 553607 to 803513 kg/day (702374 ± 82048 kg/day) in which 146.97 to 348.19 kg/day (226.18 ± 66.26 kg/day) BOD_5 discharged from sampling point-5. In the sampling point-8 it was 705054 to 982497 kg/day (871789

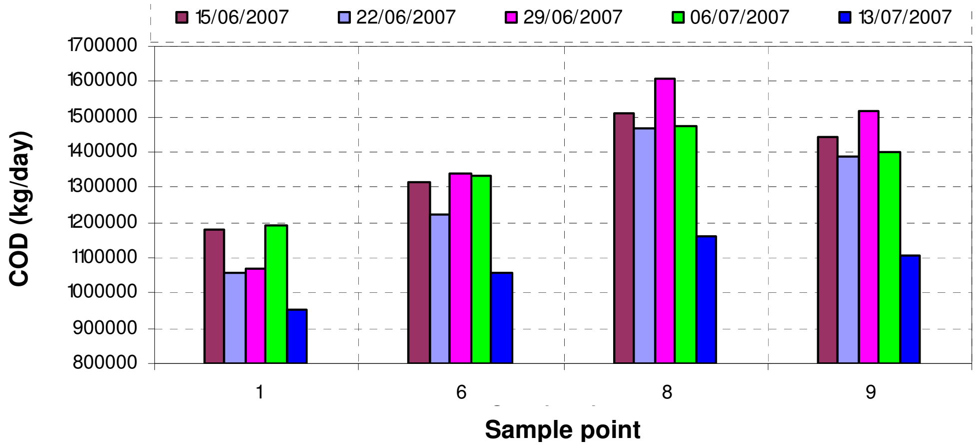

Figure 15. Variation of COD in kg/day along the Lakhya River.

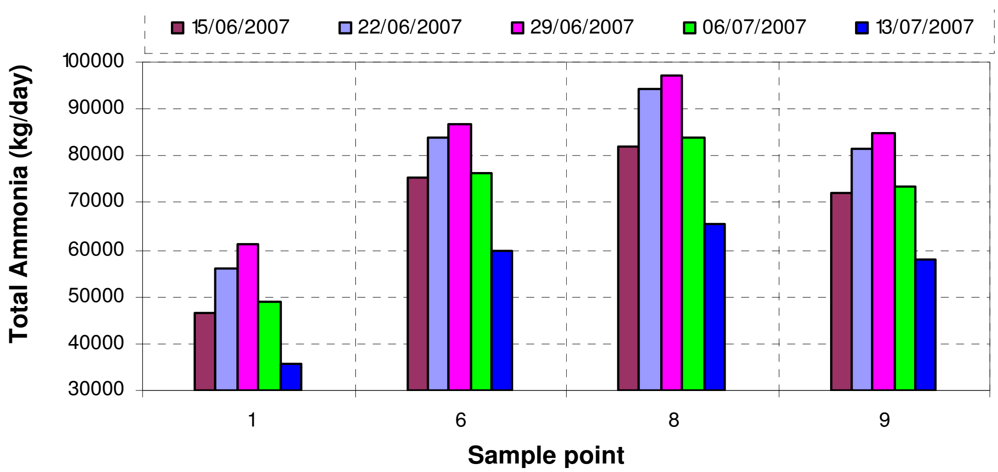

Figure 16. Variation of total ammonia in kg/day along the Lakhya River.

± 102518 kg/day) in which 2518.3 to 3094.42 kg/day (2902.92 ± 211.31 kg/day) BOD_5 discharged from sampling point-4 and 7. In the sampling point-9, it was 655124 to 982923 kg/day (802362 ± 105472 kg/day). It was shown that there was insignificant impact of pollution load of BOD_5 discharged from fertilizer factories.

Chemical oxygen demand (COD)

The amount of pollution load along the Lakhya River of COD (Figure 15) was 954971 to 1188933 kg/day (1090493 ± 86782 kg/day) in the sampling point-1. In the sampling point-6 it was 1056886 to 1339188 kg/day (1252013 ± 106198 kg/day) in which 258.94 to 595.29 kg/day (369.49 ± 118.68 kg/day) COD discharged from sampling point-5. In the sampling point-8 it was 1158303 - 1607722 kg/day (1442595 ± 150924 kg/day) in which 4455.64 to 4644.45 kg/day (4543.72 ± 67.82 kg/day) COD discharged from sampling point-4 and 7. In the sampling point-9, it was 1108672 to 1519062 kg/l (1371856 ± 139415 kg/day). It was shown that there was insignificant impact of pollution load of COD discharged from fertilizer factories.

Total ammonia (NH_3-N + NH_4-N)

The amount of pollution load along the Lakhya River of total ammonia (Figure 16) was 35686 to 61103 kg/day (49663 ± 8707 mg/l) in the sampling point-1. In the sampling point-6 it was 59890 to 86601 kg/day (76427 ± 8309 kg/day) due to 7368 to 11203 kg/day (8624 ± 1344 kg/day) total ammonia discharged from sampling point-5. In the sampling point-8 it was 65469 to 97357 kg/day

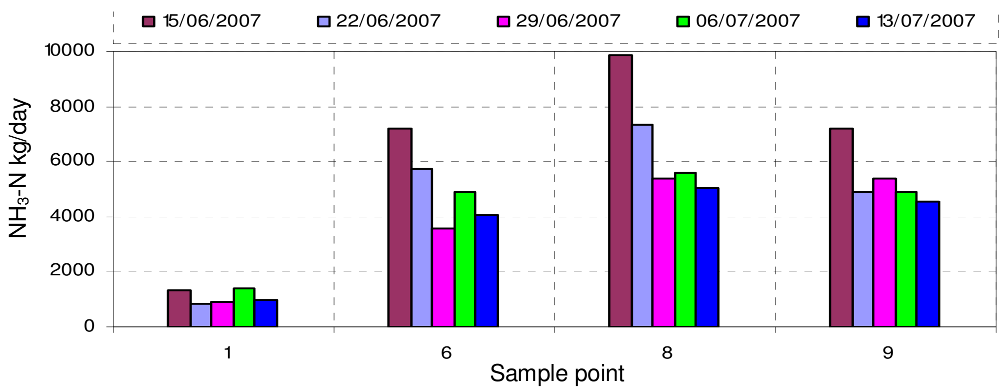

Figure 17. Variation of Ammonia as Nitrogen (NH_3-N) in kg/day along the Lakhya River.

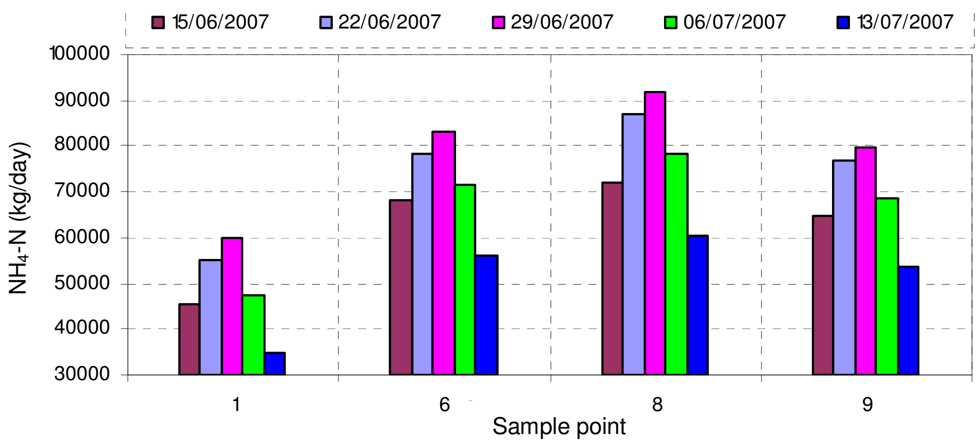

Figure 18. Variation of Ammonium as Nitrogen (NH_4-N) in kg/day along the Lakhya River.

(84685 ± 11257 kg/day) due to 8808 to 10467 kg/day (9577 ± 533 kg/day) total ammonia discharged from sampling point-4 and 7. For the dilution factor, the total ammonia reduced in the sampling point-9 and it was 57953 to 84889 kg/day (74030 ± 9336 kg/day). It was observed that fertilizer factories are the major sources of total ammonia load discharged in Lakhya River in the study area. The amount of total ammonia load in sampling point-9 is greater than the load of total ammonia in sampling point-1. This increment was due to the ammonia load discharged from fertilizer factories. So the ammonia load discharged from fertilizer factories has a large impact on the Lakhya River water quality.

Ammonia as nitrogen (NH_3-N)

The pollution load of Ammonia as Nitrogen (NH_3-N) (Figure 17) was 814 to 1399 kg/day (1084 ± 231 kg/day) in the sampling point-1. In the sampling point-6 it was 3571 to 7215 kg/day (5083 ± 1293 kg/day) due to 4975.23-6598.68 kg/day (5643.73 ± 590.45 kg/day) NH_3-N discharged from sampling point-5. In the sampling point-8 it was 5036-9840 kg/day (6635 ± 1788 kg/day) due to 2322.54 to 5265.65 kg/day (3542.03 ± 1080.86 kg/day) NH_3-N discharged from sampling point-4 and 7. For the dilution factor the NH_3-N reduced in the sampling point-9 and it was 4535 to 7217 kg/day (5383 ± 954 kg/day). It was observed that fertilizer factories are the major sources of ammonia load (NH_3-N) discharged into the Lakhya River in the study area. The amount of ammonia load in sampling point-9 is greater than the load of Ammonia in sampling point-1. This increment was due to the ammonia load discharged from fertilizer factories. So the ammonia load discharged from fertilizer factories has a large impact on water quality of the Lakhya River.

Ammonium as nitrogen (NH_4-N)

The pollution load of Ammonium as Nitrogen (NH_4-N) (Figure 18) was 34681 to 59765 kg/day (48515 ± 8670 kg/day) in the sampling point-1. In the sampling point-6 it was 55864 to 83030 kg/day (71344 ± 9300 kg/day) due to 1903.08 to 5988.22 kg/day (2980.78 ± 1541.86 kg/day)

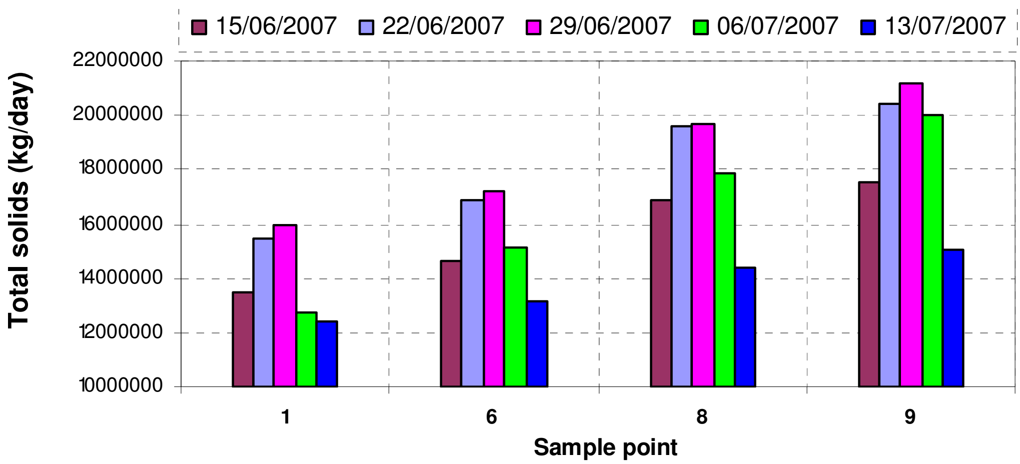

Figure 19. Variation of total solids in kg/day along the Lakhya River.

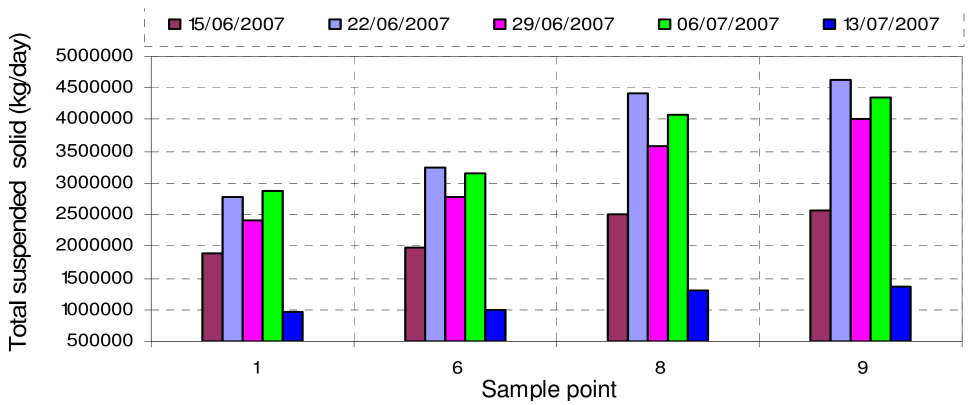

Figure 20. Variation of total suspended solids in kg/day along the Lakhya River.

NH_4-N discharged from sampling point-5. In the sampling point-8 it was 60433 to 91997 kg/day (78050 ± 11161 kg/day) due to 5201.7 to 7064.64 kg/day (6035.72 ± 687.03 kg/day) NH_4-N discharged from sampling point-4 and 7. For the dilution factor the NH_4-N reduced in the sampling point-9 and it was 53418 to 79527 kg/day (68648 ± 9245 kg/day). It was observed that fertilizer factories are the major sources of Ammonium load (NH_3-N) discharged into the Lakhya River in the study area. The amount of Ammonium load in sampling point-9 is greater than the load of Ammonium in sampling point-1. This increment was due to the Ammonium load discharged from fertilizer factories. So the Ammonium load discharged from fertilizer factories has a large impact on water quality of the Lakhya River.

Total solids (TS)

The amount of pollution load of TS (Figure 19) was 12414626 to 15967134 kg/day (14002508 ± 1444285 kg/day) in the sampling point-1. In the sampling point-6 it was 13135585 to 17230884 kg/day (15395465 ± 1501169 kg/day) in which 1523 to 3077 kg/day (1908 ± 594 kg/day) TS discharged from sampling point-5. In the sampling point-8 it was 14403247 to 19649938 kg/day (17683404 ± 1956566 kg/day) in which 5925 to 7302 kg/day (6816 ± 606.69 kg/day) TS discharged from sampling point-4 and 7. Total solids were accumulated in the downstream, for this, the load of TS were increased in the sampling point-9 and it were 15017466 to 21177516 kg/day (18831382 ± 2269732 kg/day). It was shown that the pollution load of TS discharged from sampling point 5, 4 and 7 were negligible as compared to the load discharged from residential area on the bank of the Lakhya river. So it can be concluded that there was insignificant impact of pollution load of TS discharged from fertilizer factories.

Total suspended solids (TSS)

The amount of TSS (Figure 20) was 954971 to2867428 kg/day (2179768±699440 kg/day) in the sampling point-1.

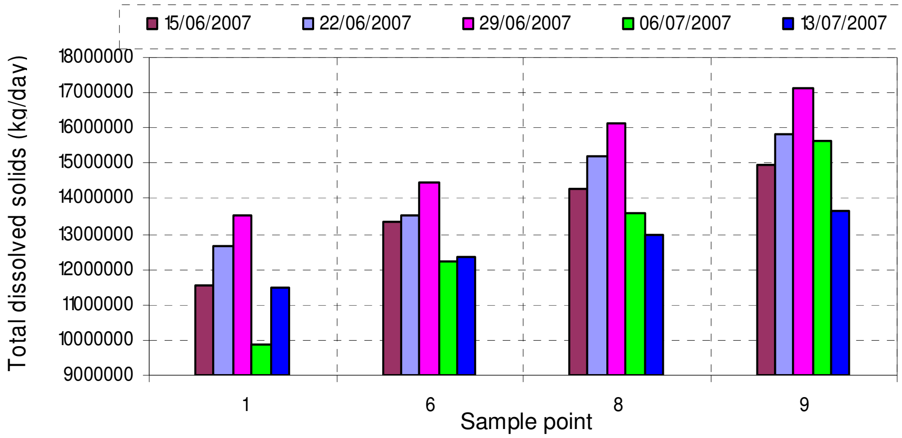

Figure 21. Variation of total dissolved solids in kg/day along the Lakhya River.

In the sampling point-6 it was 1006558 to3257035 kg/day (2430154±843632 kg/day) in which 1394 to 2623 kg/day (2060 ± 451 kg/day) TSS discharged from sampling point-5. In the sampling point-8 it was 1309386-4398998 kg/day (3167783 ± 1130850 kg/day) in which 118 to 752 kg/day (348 ± 213 kg/day) TSS discharged from sampling point-4 and 7. Total suspended solids were accumulated in the downstream, for this, the load of TSS were increased in the sampling point-9 and it were 1360643 to 4645510 kg/day (3386845 ± 1241162 kg/day). It was shown that the pollution load of TSS discharged from sampling point 5, 4 and 7 were negligible as compared to the load discharged from residential area on the bank of the Lakhya River. So it can be concluded that there was negligible impact of pollution load of TS discharged from fertilizer factories.

Total dissolved solids (TDS)

The amount of pollution load of TDS (Figure 21) was 9861153 to 13558684 kg/day (11822740 ± 1251002 kg/day) in the sampling point-1. In the sampling point-6 it was 12256499 to 14463229 kg/day (13176508 ± 818925 kg/day) in which 1394 to 2623 kg/day (2060 ± 451 kg/day) TDS discharged from sampling point-5. In the sampling point-8 it was 12942778 to 16166540 kg/day (14448096 ± 1147385 kg/day) in which 118 to 752 kg/day (348 ± 213 kg/day) TDS discharged from sampling point-4 and 7. TDS were accumulated in the downstream, for this, the load of TDS were increased in the sampling point-9 and it were 13656823 to 17156469 kg/day (15444538 ± 1143304 kg/day). It was shown that the pollution load of TDS discharged from sampling point 5, 4 and 7 were negligible as compared to the load discharged from residential area on the bank of the Lakhya River. So it can be concluded that there was negligible impact of pollution load of TS discharged from fertilizer factories.

Schematic figures of water quality parameters for different sources along the Lakhya River are shown in Figures 22 to 27.

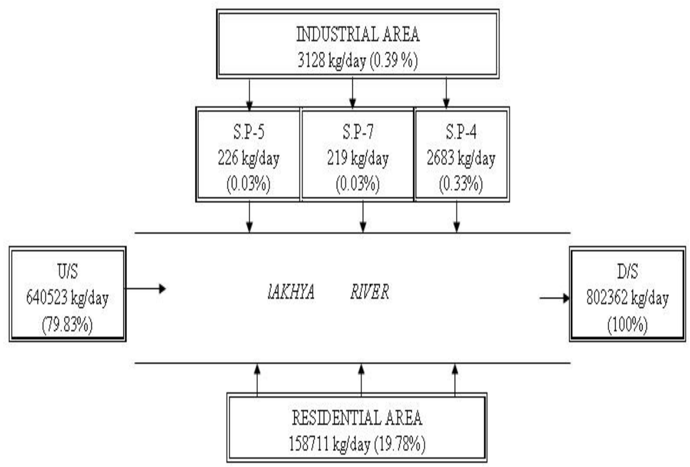

Figure 22. Different sources of BOD_5 along the Lakhya River.

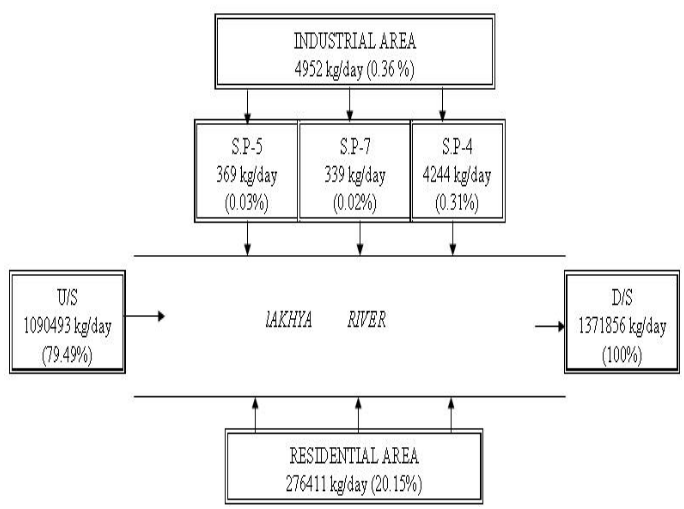

Figure 23. Different sources of COD along the Lakhya River.

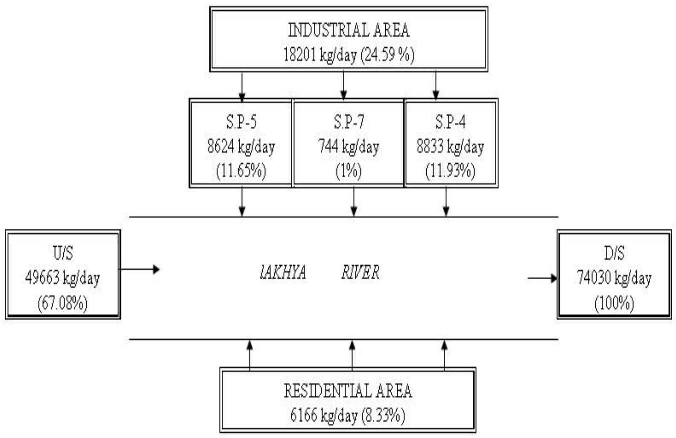

Figure 24. Different sources of Ammonia along the Lakhya River.

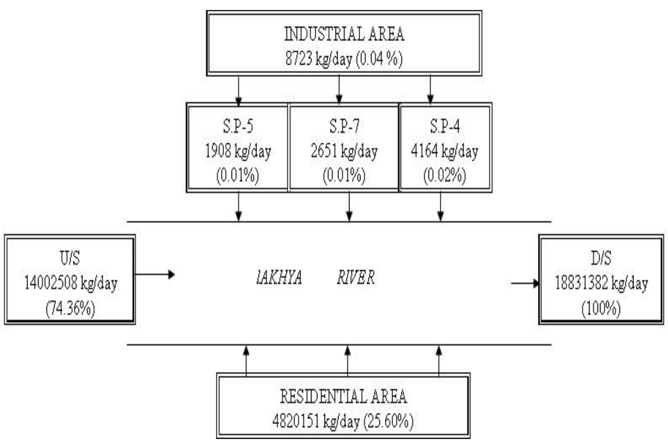

Figure 25. Different sources of total solids along the Lakhya River.

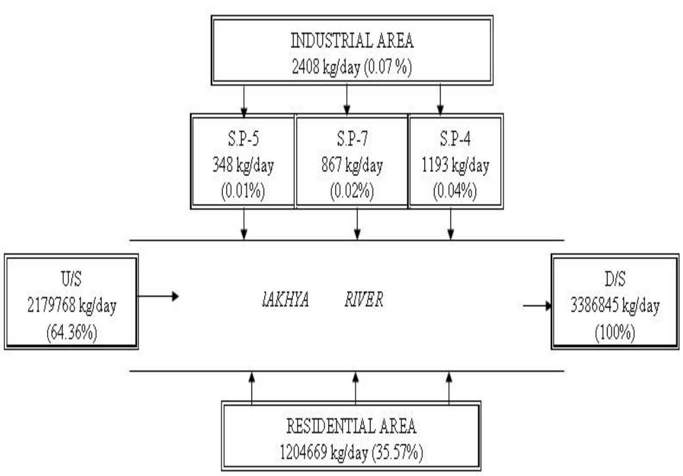

Figure 26. Different sources of total suspended solids along the Lakhya River.

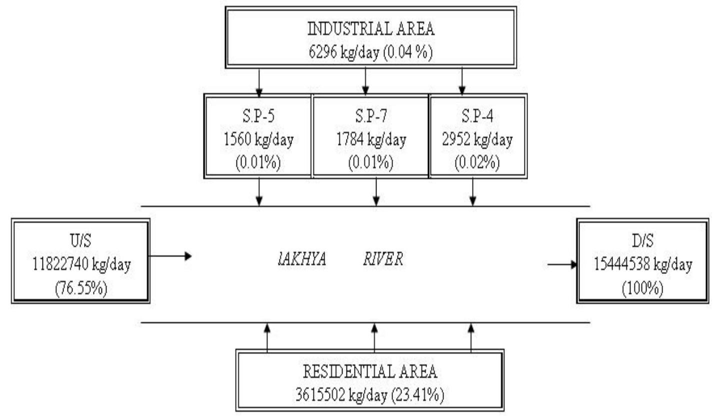

Figure 27. Different sources of total dissolved solids along the Lakhya River.

DISCUSSION

(1) The concentration of most of the water quality parameters in down stream (sampling point-9) is greater than the concentration in up stream (sampling point-1).

(2) In the sampling point-1, the level of BOD_5, COD, DO, pH, Temperature, Total Ammonia, Ammonia as Nitrogen (NH_3-N), Ammonium as Nitrogen (NH_4-N), TS, TSS, TDS was 9.2, 15.8 and 4.476 mg/l, 7.66, 29.68°C, 0.69, 0.016, 0.68, 200, 30 and 170 mg/l respectively. In the sampling point-9, these were 11.4, 19.6, 3.95 and 8.16, 29.72°C, 1.05, 0.078, 0.97, 267.6, 46 and 221.6 mg/l respectively.

(3) In the sampling point-1, the amount of BOD_5, COD, total ammonia, Ammonia as Nitrogen (NH_3-N), Ammonium as Nitrogen (NH_4-N), TS, TSS, TDS was 640523, 1090493, 49663, 1084, 48515, 14002508, 2179768 and 11822740 kg/day respectively. In the sampling point-9, these were 802362, 1371856, 74030, 5383, 53418, 1883138, 3386845 kg/day and 15444538 kg/day, respectively.

(4) The total amount of pollution load discharged from fertilizer factories into the Lakhya River were BOD_5 were 2665 to 3369 kg/day, COD were 4714-5221 kg/day, Total Ammonia (NH_3-N) were 17425 to 20012 kg/day, Ammonia as Nitrogen (NH_3-N) were 7850.68 to 10671.21 kg/day, Ammonium as Nitrogen (NH_4-N) were 7164.34-12161.79 kg/day, TS were 7449 to 10380 kg/day, TSS were 1513 to 3375 kg/day, TDS were 5467 to 7004 kg/day

(5) It was observed that fertilizer factories are the major sources of Total ammonia load discharged into the Lakhya River in the study area. The amount of total ammonia load in the sampling point-9 is greater than the load of Total Ammonia in the sampling point-1. This increment was due to the Ammonia load discharged from fertilizer factories. So the Ammonia load discharged from fertilizer factories has a large impact on the Lakhya River water quality. It was also shown that the pollution load of BOD, COD and TS discharged from sampling point 5, 4 and 7 were negligible as compared to the load discharged from residential

area on the right bank of the Lakhya River. So it can be concluded that there was insignificant impact of BOD, COD and TS load discharged from fertilizer factories.
(6) Contribution of different sources are for total Ammonia: u/s 67.08%, fertilizer factories 24.59%, residential area 8.33% ; BOD_5: u/s 79.83%, fertilizer factories 0.39%, residential area 19.78%; COD: u/s 79.49%, fertilizer factories 0.36%, residential area 20.15%; TS: u/s 74.36%, fertilizer factories 0.04%, residential area 25.60%; TSS: u/s 64.36%, fertilizer factories 0.07%, residential area 35.57%; TDS: u/s 76.55%, fertilizer factories 0.04%, residential area 23.41%;

Conclusion

The study has shown that the effluents from the industries have a big impact on the water quality of the Lakhya River. Although, the values of some water quality 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 unless the authorities implement the laws governing the disposal of wastes this may affect the lives of the people. The river water after the effluent receiving points was alkaline (average pH, 8.16 $\pm$ 0.08) and the levels of other parameters were high due to heavy pollution load especially Ammonia discharged from fertilizer factories. The results suggested that water in the river was polluted and not good for human consumption. It is therefore recommended that the disposal of improperly treated or untreated wastes should be stopped to save the river water from further deterioration.

RECOMMENDATIONS

(1) Treatment process must be updated as high level of Ammonia was found on the test result and untreated effluent discharged from fertilizer factories through the sampling point-4, 5 must be stopped.
(2) The retaining period of effluent in lagoon was not sufficient as the effluent enters in the lagoon on one side and exit on the other side. So it is necessary to increase retaining period. It is also noted that the capacity of lagoon should be increased as in the rainy season flooding were occurred in the lagoon.
(3) Leakage from pipeline, valves or ammonia storage tank should be prevented through regular maintenance.
(4) The ground water quality in and around the factory should be checked periodically in order to ensure no adverse effect on the ground water quality.
(6) Smooth and effective implementation of laws and regulations should be ensured.

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