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An Evaluation of Environmental and Social Impact due to Industrial Activities -A Case Study of Bangshi River around Dhaka Export Processing Zone (DEPZ), Bangladesh

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Abstract

This paper reports the environmental and social impacts of industrial activities with special focus on Bangshi River and its surrounded areas. Bangshi River and adjacent areas in the vicinity of Dhaka export processing zone (DEPZ) were selected for the study. Various parameters like pH, electrical conductivity (EC) and total dissolve solid (TDS) was determined to see the quality and suitability for domestic and irrigation purposes of water samples. Flow rate of polluted Nolam Konda canal which is connected from the discharge point of different industries in DEPZ to Bangshi River was estimated. The study reveals the most industries in this area use large volume of water but without efficient wastewater treatment plants and so routinely discharge their wastes directly into the river. It also reveals the unfavorable influence of industrial activities which are responsible for the impacts on study areas. The investigation indicates that the water samples are found unsuitable for aquatic life, human consumption and also not safe for irrigation and domestic purposes. Periodic monitoring of water quality indicators is therefore essential for assessing and protecting the integrity of the ecosystem. It has the advantages of identifying changes in water quality, discovery of rising water quality problems, the evaluation of pollution control measures, the effectiveness of observance and how to respond in an emergency response.

Keywords: Industrial activities, water quality, environmental impact, social impact, Bangshi River, Bangladesh

Introduction

"No life without water'' is a common saying, as water is the essential requirement of all life supporting activities. From different sources water can be obtained such as wells, ponds, rivers, lakes etc. but unfortunately, clean, pure and safe water exists only briefly in nature and is immediately polluted by existing environmental factors and human activities and hence water from most sources is unsuitable for consumption and other purposes without some sort of treatment[1] . Destruction trends of water are the key to human survival, development progressions and success. However, the current global fresh water source is alarming for sustainable development. The water use conflicts among different sectors i.e. agriculture, industry and urbanization and pollution of surface/river water due to industrialization and other anthropogenic causes are too high in developing country.

Bangladesh is said to be the land of rivers. Although this global recognition is largely attributed to the 'floods' and not the extensive network of rivers and other water bodies that this country is blessed with, the fact remains that lives and livelihood in this riverine country are intertwined with its rivers and the innumerable number of other water bodies. It is often argued that if the definition of wetlands as given in the Ramsar Convention is applied, then two-thirds of the total area will be recognized as wetlands[2].According to Bangladesh Water Development Board (BWDB), the country has as many as 310 rivers of which 54 major rivers are shared with India while 3 are shared with Myanmar. The Padma, Meghna, Jamuna, Brahamaputra, Teesta, Surma and Karnaphuli are considered the principal rivers of the country which are also at the same time, the play land of nature as cyclone, seasonal floods and river erosions are very common.

The 238 kilometer long Bangshi River is one of the important tributaries of Barhamaputra-Jamuna river system in Bangladesh which is the central property resource for local people.

By the River bank fewer villages are situated like Kanda, Kaichabari, Subandhi, Dagartali, Nolam, Hajipur, Sinduria, Noyapara, Pathalia and so on. Most of the people from these mentioned villages are directly and indirectly depended on this river. "About 2,68,900 people live in this area with 84% of households being involved in fishing, and 15 % of households are full time fishers (before establishing DEPZ, 1993)"[3]. This river had great fame because of its fish and the water of Bangshi River was used in agricultural purposes, household purposes and so on before industrial activities.

As of today, the contribution of agriculture in GDP is highest 22% and absorbing largest 48.1% employments of the country while industrial production and manufacturing contributes 17% in GDP but no data available of absorbent of labor force[4].

Industrialization can play significant role in development which will provide the necessary economic boost that will help us becoming a poor country to a middle economy country. By realizing this fact, our policy makers took decision about encouraging industrialization and export-oriented industrial setup. The first Export Processing Zone (EPZ) was established at the port city Chittagong in 1983 while second one which is known as DEPZ was established at Savar in Dhaka near river Bangshi in 1993[5]. DEPZ has 92 industrial units which are categorically the leading pollution creators[6]. These industrial units in number show in table 1.

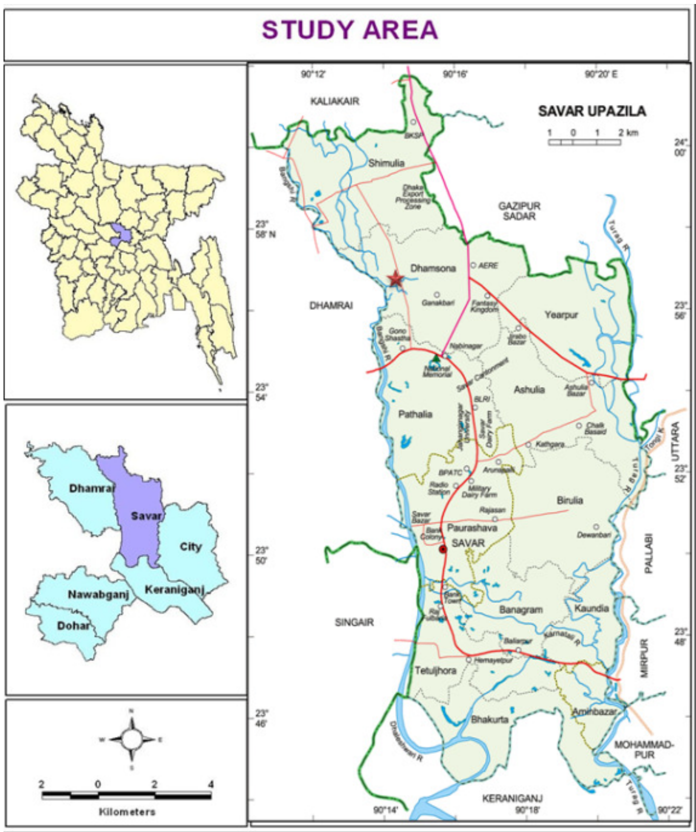

Figure-1
Map of Bangshi River

Table-1
Number of Industrial units in DEPZ

Industries	Number
Cap/accessories/garments	42
Textile/knitting	22
Plastic goods	6
Footwear/ leader goods	4
Metal products	2
Electronic goods	2
Paper products	1
Chemical and fertilizer	1
Miscellaneous	11

Since the initiation of DEPZ, the Banghsi River is consistently being polluted by industrial waste disposal which in turns threatened the natural environment of the riverine areas.

Table-2
Wastewater discharge rate from DEPZ to Bangshi River[7]

Cluster Name	Discharge point	Wastewater discharge (m^3/sec)
DEPZ	EPZ gate	0.633
	Nolam Konda Canal	1.270
	Sokundi Canal	0.181

Figure-2
The present scenario of Bangshi River
(water become dark black due to industrial activities)

The main concern in this study is to understand and explain how industrialization and its pollution to rivers induce social change and affects the environment, ecology and livelihoods around the Bangshi River areas. A very important objective of this study is to identify the problems of the area and their possible mitigation process.

Material and Methods

Materials: There are various instruments which were used in this study. They are – i. GPS-Explorist 200, ii. Griffin pH meter, model No.40, iii. Paul Smith digital TDS Meter, iv. Digital EC Meter (Model CON6), v. Digital camera. vi. Sample bags. vii. Sample bottle, viii. Location map etc.

Methodology is one of the most important parts of any investigation. It is the way by which the study is conducted. It includes some chronological steps that are necessary to complete the study successfully. Questionnaire survey, visual observation, sampling, mapping and photography methods have been used in this study.

Sources of Bangshi River pollution: i. Major type of industries include ceramic industry, beverage industry, press and publication, garments industry, foot ware, jute mills, textile mills, printing and dying factory, transformer industry, automobile industry, biscuit and bread factory, pharmaceutical industry, soap factory, brick field, cold storage, welding, plant nursery and so on. Bangladesh Export Processing Zone is located near the river. ii. Textile Dying Industries: There are approximate 80% are textile dying industries dispose their waste water in Dhalai Beel that connected with Bangshi River. In this study area, textile dying industries discharge huge amount of effluents, sewage sludge, and solid waste materials directly into the surrounding area.

Sampling: Sampling Protocol: Sample protocol in field monitoring was followed carefully, foreign particle that may affect the result. Samples were collected very carefully as all interception are based on the analyses report: 1000 ml of Plastic bottle were used for sampling purposes. i. The container was washed prior to sampling with 1M HNO_3 solution and then rinsed thoroughly with de-ionized water. ii. The sample poured in the bottles by a plastic cap. iii. the samples are preserved carefully in refrigerators.

Sample collection: Water sampling was started from upstream of river (the point, 23^{0}56'39" N - 90^{0}40'00" E), continued downstream at an interval. Total number of samples collected during field was 13. Location was confirmed by GPS reading. Water samples were collected at each point with water sampler in the midstream at a depth of 1 to 2 feet to avoid the interference of the floating substances.

pH Determination: The acidic or alkaline condition of the water is expressed by pH. The pH of water sample was determined by using a glass electrode pH meter (Griffin pH meter, model No.40). The electrode was rinsed thoroughly by using distilled water and wiped by using tissue paper. The electrode was dipped into the sample water and was kept until the stable reading was observed. The final reading was recorded.

EC Determination: The EC measures the salinity of water and depends on the ions present in water [8]. The EC of water sample was determined by using a digital EC meter (model CON6). The electrode of EC meter was rinsed thoroughly by using distilled water and wiped by using tissue paper. The electrode was dipped into the sample water and was kept until the stable reading was observed. The final reading was recorded.

TDS Determination: TDS give the total concentration of dissolved solids in a water sample. Among these dissolved solids could be phosphates, nitrates, alkalis, some acids, sulphates, iron, and magnesium etc[9]. The TDS of water sample was determined by using a Paul Smith digital TDS Meter. The glass electrode of TDS meter was rinsed thoroughly by using distilled water and wiped by using tissue paper. The electrode was dipped into the sample water and was kept until the stable reading was observed. The final reading was recorded.

Figure-3
Location of the Sampling point on Google map (Bangshi River)

Flow rate determination of polluted Nolam Konda canal: Flow rate is the amount of fluid that flows in a given time. By the determination of flow rate of this canal, it can be assumed that how effectively industrial wastewater drops into the Bangshi River. The width and depth of a certain area of the canal was determined and calculated the total area. Mean velocity of water was determined through a small leaf spend how much time to cross a required distance. Finally, by using the following formula the flow rate of polluted Nolam Konda canal was determined.

Formula: $Q = \bar{u} \times A$

Here, Q = Flow rate, $\bar{u}$ = Mean velocity, A = Cross sectional area.

Questionnaire survey: A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents[10]. Basically, this methodology was used to collect information about the impacts of industrialization near the Bangshi River areas. For this survey, respondents were selected whose age limit was between 25 and 50 years old and directly or indirectly connected with the impact of industrial pollution on Bangshi River.

Table-3
Detail of Bangshi River water sample

Sample No.	GPS Position	Distance (Km)	Location	P^H	EC (µs)	TDS (mg/l)
Sample 1	23°56′39″ N 90°40′00″ E	0	Kamalshi	8.16	2.42×10^4	1599
Sample 2	23°56′16″ N 90°13′52″ E	.96	Norekandi	7.97	2.15×10^4	1406
Sample 3	23°56′14″ N 90°13′53″ E	1.03	Nolam	7.77	2.20×10^4	1450
Sample 4	23°56′05″ N 90°13′39″ E	1.74	Nolam	7.82	2.12×10^4	1441
Sample 5	23°55′44″ N 90°13′35″ E	2.36	Nolam	8.02	2.16×10^4	1448
Sample 6	23°55′40″ N 90°13′28″ E	2.57	Pathalia	7.95	2.19×10^4	1440
Sample 7	23°55′23″ N 90°13′34″ E	3.14	Pathalia	7.92	2.22×10^4	1454
Sample 8	23°54′37″ N 90°13′49″ E	4.48	Noyerhat	7.90	2.15×10^4	1438
Sample 9	23°54′07″ N 90°13′45″ E	5.14	Noyerhat	7.79	2.06×10^4	1367
Sample 10	23°53′44″ N 90°13′51″ E	5.76	Ghughudia	7.72	1.87×10^4	1271
Sample 11	23°53′23″ N 90°13′51″ E	6.2	Ghughudia	7.68	1.83×10^4	1204
Sample 12	23°52′52″ N 90°13′56″ E	6.47	Sinduria	7.52	1.73×10^4	1106
Sample 13	23°51′54″ N 90°14′12″ E	10.01	Sinduria	7.04	1.47×10^4	980

Results and Discussion

The result obtained from the physicochemical analysis of water samples collected from thirteen different sampling points (is given in table 3), questioner survey and visual observation.

pH: The DOE standard pH value of surface water is 6.5 to 8.5. The pH value for first sample is 8.16 which is also the highest pH value among these 13 samples. Then the pH value slowly decreases for second and third sample. Fourth and fifth sample represents slight increase while the rest samples decreases again. So, among these water samples, pH value shows a trend to decrease with distance as these waters are mixed with high volume river water. Maximum pH value is 8.16 while minimum pH value is 7.04. So, the pH of water sample ranges from 7.04 to 8.16 which remain within the DOE standard.

EC Determination: The EC measures the salinity of water and depends on the ions present in water [8]. The EC of water sample was determined by using a digital EC meter (model CON6). The electrode of EC meter was rinsed thoroughly by using distilled water and wiped by using tissue paper. The electrode was dipped into the sample water and was kept until the stable reading was observed. The final reading was recorded.

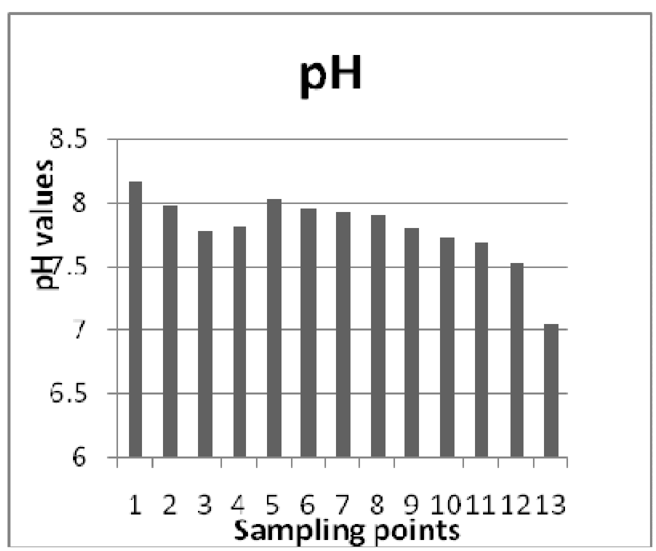

Figure-4
Mean value of pH at different sampling points

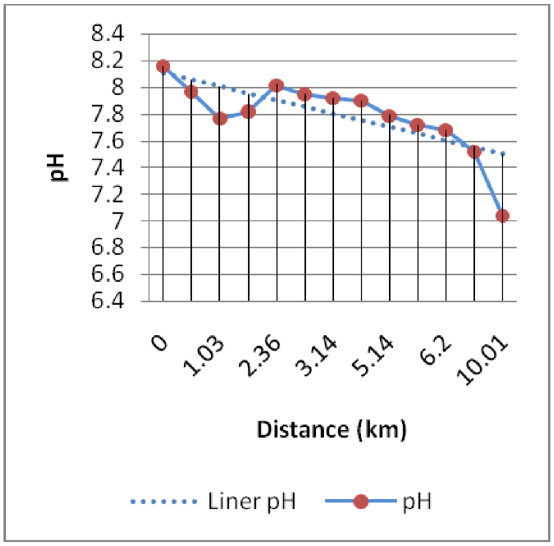

Figure-5
Change of pH with distance

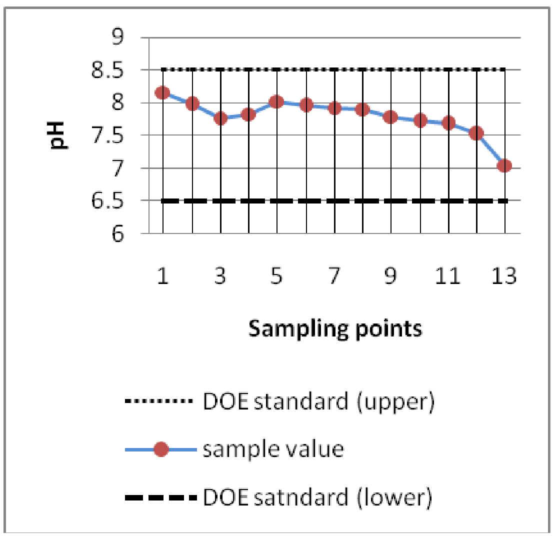

Figure-6
Comparison between mean value of pH and DOE standard

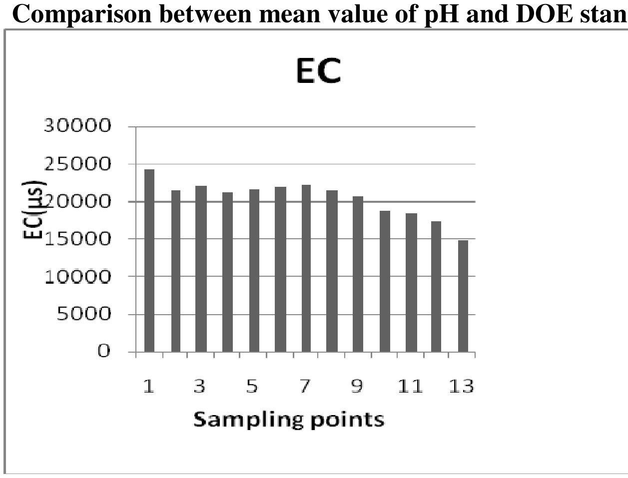

Figure-7
Mean value of EC at different sampling points

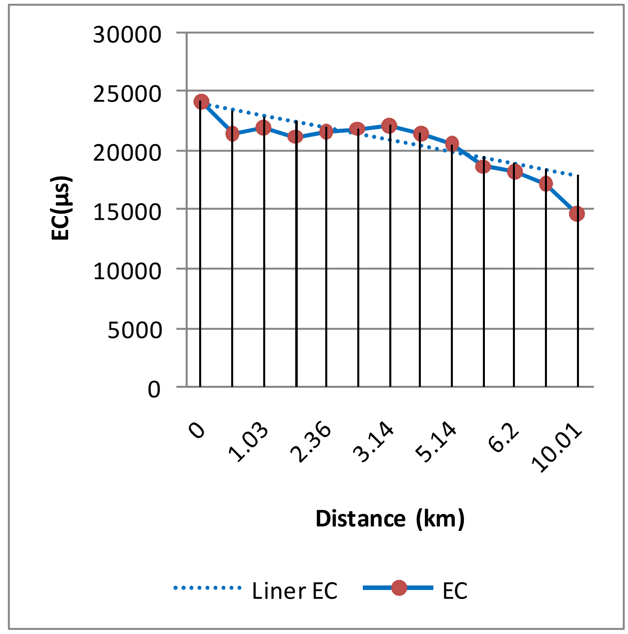

Figure-8
Change of EC with distance

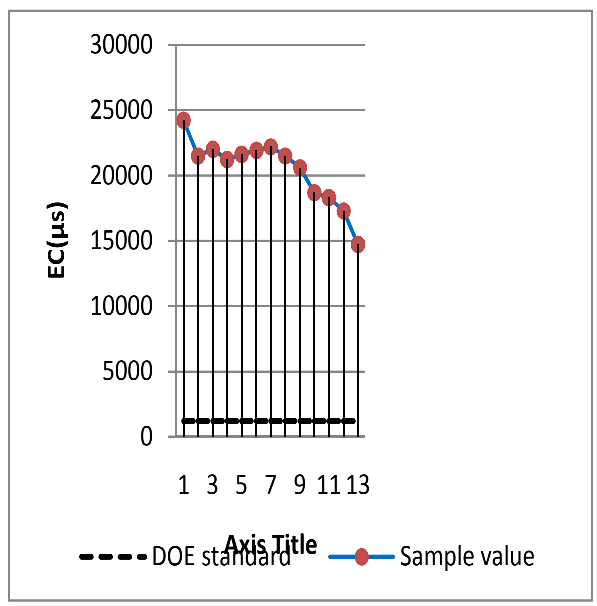

Figure-9
Comparison between mean value of EC and DOE standard

TDS Determination: TDS give the total concentration of dissolved solids in a water sample. Among these dissolved solids could be phosphates, nitrates, alkalis, some acids, sulphates, iron, and magnesium etc[9]. The TDS of water sample was determined by using a Paul Smith digital TDS Meter. The glass electrode of TDS meter was rinsed thoroughly by using distilled water and wiped by using tissue paper. The electrode was dipped into the sample water and was kept until the stable reading was observed. The final reading was recorded.

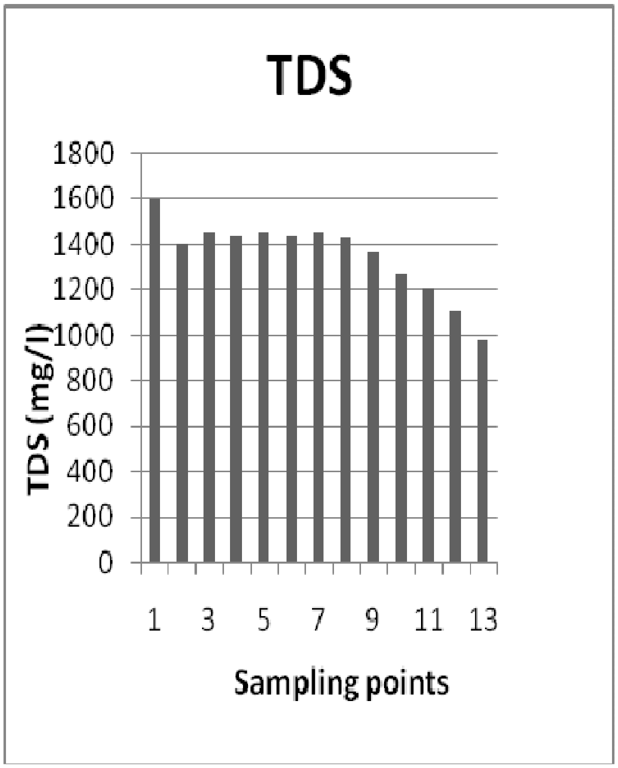

Figure-10
Mean value of TDS at different sampling points

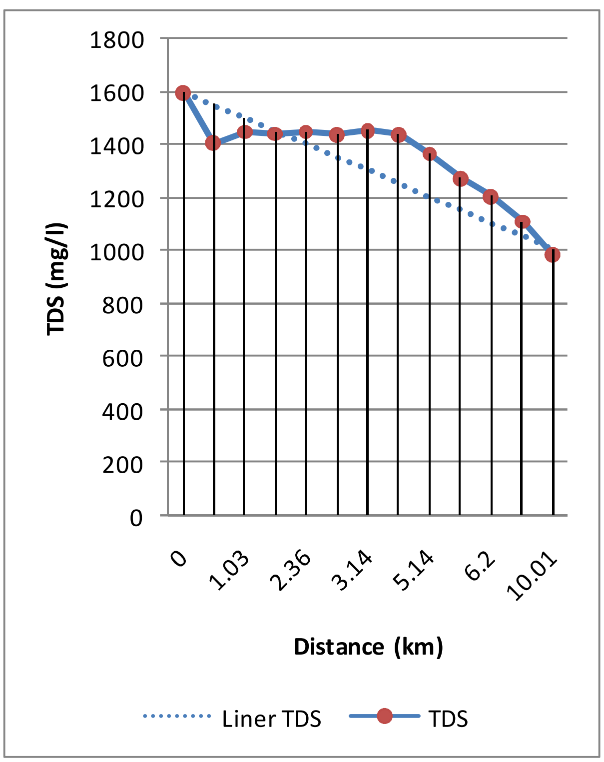

Figure-11
Change of TDS with distance

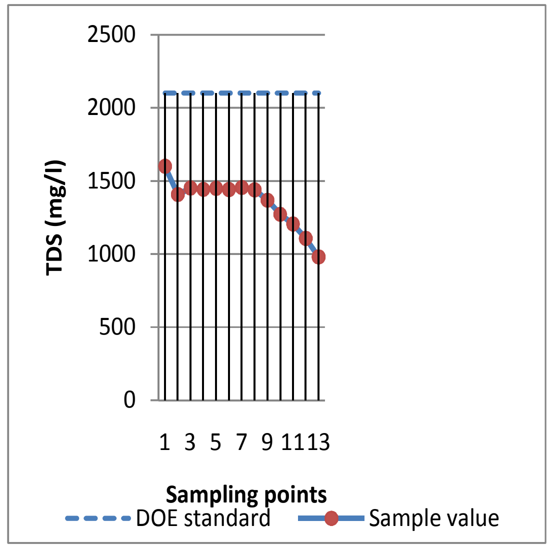

Figure-12
Comparison between mean value of TDS and DOE standard

Color and Odor: The color of water of the river was dark black. The smell of the river water was also very offensive. By seeing this characteristic color and having such offensive smell, one can easily conclude that the river may have been seriously polluted.

Figure-13
Dark black color of Bangshi River

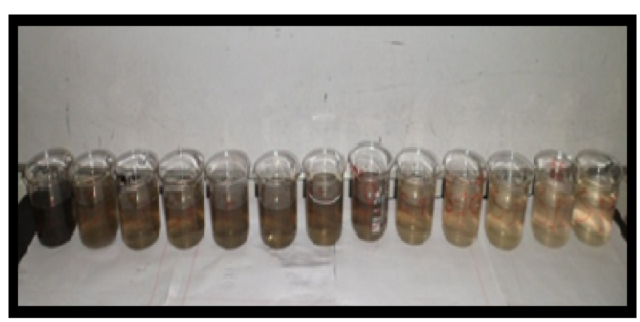

Figure-14
Color variation of the water sample from Upstream to Downstream of Bangshi River

(a) Flow rate estimation of polluted canal

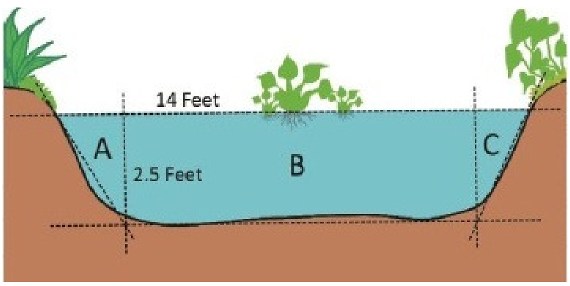

Figure-15
The Nolam Kunda canal (a) and its cross section (b)

The Width of the canal is 14 ft. and depth is 2.5 ft. Let us consider the average width is 11.5 ft.

Then, the cross sectional area (A+B+C) = 1/2×2.5×11.5 = 28.75 ft² = A

In order to cross 40 feet the water spends 29sec then, Mean velocity $\bar{u}$ =40/29 = 1.379 ft/sec, flow rate Q = $\bar{u}$ × A = 39.646 ft³/sec. So, the flow rate of waste water to river is approximately 40 ft³/sec.

Environmental and Social Impact and Mitigation option: Environmental Impacts: DEPZ industries are responsible for discharging huge amount of effluents into the adjacent Nolam Kunda Khal (wet land), land, agricultural fields, irrigation channels and surface water and finally enter into the Bangshi River. For this a large number of villages are now being threatened by this environmental pollution.

Social Impact analysis (based on questionnaire survey): In brief social impacts can be categories into positive and negative. i. Positive impacts: 1. Employment of local people due to the development of different industries. 2. Empowerment of women. 3. Improvement of local and national economy through earning foreign currency. 4. Increasing rate of education. 5. Infrastructural development of local area. 6. Development of communication system. 7. The EPZ and other industries create 350 additional employments for women in the village.

Table-4
Impacts on water quality (Field observation)

Sources of the pollution	**pH**	**EC (µS)**	**TDS (mg/l)**
SW-1	8.08	2.18×10^4	1411
SW-2	7.74	2.33×10^4	1510
Standard value	SW 6-9	SW 1200	SW 2100
Assessment of the pollution		The ranges of pH, TDS are within limit. But the limit of EC is out of control. On the other hand The color and odor of the river water are not desirable.	
Impacts on the inhabitants		Local people can't use this water in any purposes; people who get contact with this water are affected by skin irritation.	
Recommendation for mitigation		Proper treatment of effluent by using ETP.	

Table-5
Impacts on Agriculture (Field observation and questionnaire survey)

Agricultural Activity	Seasonal variation	
	Dry Season	**Wet season**
Irrigation water source	Surface + Ground water	Surface + Ground Water
Crop pattern	Paddy, Some vegetables.	Paddy
Crop pattern change	Fewer varieties of vegetables and robi crops, less production of paddy.	Less production of paddy.
Productivity change	Low productivity	Low productivity
Impacts on the inhabitants	Crisis of agricultural products and employment problem of farmers.	
Recommendation for mitigation	Use of organic fertilizers, rain water harvesting, limited discharge of untreated industrial effluent etc.	

ii. Negative impacts: 1. Loss of employment of the farmer due to the loss of soil fertility. 2. Demographic change. 3. Change of occupation. 4. Increasing daily expense due to the changing lifestyle. 5. Change in mode of recreation with respect to river use pattern. 6. Relocation of housing due to the pungent smell of river water. 7. Cultural change. 8. Impacts on health (mainly skin irritation). 9. Excess increase of mosquito, fly and other insects. 10. Reduction of paddy production due to the loss of soil fertility. 11. Outbreak of plant diseases. 12. Loss of navigation system. 13. Deforestation of the adjacent area of the Bangshi River. 14. Increasing cost for irrigation. 15. Fisherman get job only in rainy season. 16. The EPZ and other industries make jobless 170 traditional fishing families.

Table-6
Variations in social aspects before and after industrial activities

Issues	Variations	
	Before Industrial Activity	After Industrial Activity
Education	Low	Increase
Migration of People	No	Increase
Occupational Change	No	Increase
Cultural Change	Low	High
Economic Change	Low	High
Social Security	Low	Medium
Communication Development	Under developed	Developed
Aesthetic Change	High	Decrease
Infrastructural Change	Low	Increase

Management and Mitigation Strategy: River restoration: River restoration projects aim to maintain or increase ecosystem goods and services while protecting downstream and coastal ecosystems. There is growing interest in applying river restoration techniques to solve environmental problems, yet little agreement exists on what constitutes a successful river restoration effort. Five criteria are proposed for measuring success, with emphasis on an ecological perspective. First, the design of an ecological river restoration project should be based on a specified guiding image of a more dynamic, healthy river that could exist at the site. Secondly, the river's ecological condition must be measurably improved. Thirdly, the river system must be more self-sustaining and resilient to external perturbations so that only minimal follow-up maintenance is needed. Fourthly, during the construction phase, no lasting harm should be inflicted on the ecosystem. Fifthly, both pre- and post-assessment must be completed and data made publicly available. Standards are needed because progress in the science and practice of river restoration has been hampered by the lack of agreed upon criteria for judging ecological success. Without well-accepted criteria that are ultimately supported by funding and implementing agencies, there is little incentive for practitioners to assess and report restoration outcomes. Improving methods and weighing the ecological benefits of various restoration approaches require organized national-level reporting systems. The success of a restoration project could be evaluated in many different ways. Restore a river or stream must also be judged on whether the restoration is an ecological success.

Mitigation of industrial pollution: Mitigation of industrial pollution would be required for all the existing industrial clusters considered in this study. Mitigation is also needed for isolated individual industries located outside apart from these clusters. The mitigation strategy could be classified in four broad categories: i. Policy Intervention, ii. Management Intervention, iii. Technical Option, iv. Awareness Rising.

Recognizing the recent paradigm shift from costly mitigation measures through treatment to cost-effective environmental management, improved environmental performance in the industrial clusters could be achieved through a combination of policy intervention, good management practices, technical control measures and raise awareness among the owners and general mass.

i. Policy intervention may include: 1. Ensuring effective environmental assessment through industrial audit 2. Develop policy and promotion of cleaner production technology (CP) 3. Introducing pollution charges permit system (polluter pay) 4. Setting realistic ambient standards for different industries 5. Include public involvement. ii. Management intervention should include: 1. Maintaining good housekeeping and internal environmental management within the industries 2. Adopting ISO 14000 series in industries 3. Waste reduction in industrial processes and adopt pollution prevention techniques. iii. Technical option may include: Wastewater treatment option for particular industry would depend on the following factor: 1. Characteristics of wastewater 2. Wastewater flow rate 3. Discharge standard 4. Environmental rules and regulations 5. Operation cost of treatment. In general, treatment option may be broadly divided into three major classes: 1. Primary Treatment (physico-chemical treatment) 2. Secondary treatment (biological treatment) 3. Tertiary treatment (nutrient removal). Both physic-chemical treatment followed by biological treatment is generally required for textile dyeing industries those are inside the DEPZ which are responsible for polluting the "Bangshi river" iv. Awareness development should include: 1. Prepare booklets and distribute to the industry owner for dissemination of information 2. Provide information through media 3. Provide training facilities for the industry requirement.

Conclusion

From the above study it can be concluded that most of the industrial pollutants are directly or indirectly discharged into Bangshi River. Pollutants entering the water body are both in solid and liquid forms. As a result, water of Bangshi River becomes highly polluted and unsuitable for domestic and irrigation purposes. The effects of this pollution on public health and environment are usually great in magnitude. These include endangering of aquatic resources as well as for flora and fauna. The industrial activities of DEPZ have both environmental and social impact around the bank of Bangshi River. Wastewater treatment is probably the most obvious mitigation measure and river restoration is the most management strategy which can check the adverse environmental and social consequences.

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