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IMPACTS OF INDUSTRIAL EFFLUENTS ON ASAN RIVER, DOON VALLEY

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ABSTRACT

The present study evaluates various physico-chemical parameters and presence of phytoplanktons, invertebrates and fishes in the Asan river water due to effluents released into it by some industries at Selaqui in Dehradun district of Uttarakhand. Two sampling sites, S_1 and S_2, reference and impacted, respectively, were selected for determining the impact of pollutants on the characteristics of the water, phytoplanktons, invertebrates and fishes.

The main alteration in impacted site observed were change in pH, decrease in dissolved oxygen, biological oxygen demand, chemical oxygen demand, and increase in free CO_2, turbidity, hardness etc. The number of aquatic animals decreased due to the discharge of effluents and pollutants. Several control measures are needed to check the pollution of river water caused by the discharge of effluents from industries.

Key words: Industrial effluent, water quality.

INTRODUCTION

Water, the elixir of life, has been depleted and turned into scarce commodity with increased usage catering to the needs of ever-expanding population. There is almost a global shortage of water and the world's most urgent and front rank problem today is

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supply and maintenance of clean drinking water. In the recent past, expanding human population, industrialization, intensive agricultural practices and discharge of massive amount of wastewater into the rivers have resulted in deterioration of water quality. The anthropogenic activities have resulted in scarcity of potable water supply and loss of biodiversity in aquatic ecosystems. Although on the global scale, the problem due to disposal of untreated waste on water quality, biotic communities and indeed on human health were recognized in 1900s[1], the progress in the wastewater treatment has not gained momentum in the third world countries, especially India.

The disposal of industrial effluents is of widespread national concern. Industrial activities generate a large number and variety of waste disposal which are discharged into water streams. The nature of industrial effluents depends upon the industrial process in which they originate. The problem of adequately handling the industrial effluents is more complex and much more difficult than sewage, because industrial effluents vary in nature from relatively less clean to waste liquor that are heavily loaded with organic, mineral matter, corrosive, poisonous, inflammable or explosive substances.

The rapid industrialization alters the quality of soil, water and air due to pollution by industrial wastage. The studies pertaining to river pollution both in India and elsewhere have been conducted by various workers. Some workers have attempted to study on some physicochemical parameters of water samples of *nullahas*[2] and industrial effluents in relation to biological characteristics and other limnological parameters such as zooplankton, macrobenthos and fishes[3-7]. Some authors have worked on aquatic insects as indicators and self-purification of water[8,9]. Saxena *et al.*[10] demonstrated a heavy organic load by several industrial units in the river Ganga at Kanpur. Bhatt and Pathak[11] observed a marked change in the seasonal rhythm in physico-chemical characteristics of river Gomti in Kumaun Himalaya[11]. In Western Uttarakhand, the studies on several rivers in relation to pollution have also been conducted[12-15].

The effects of effluents even reduce the rate of germination of seeds[16], biochemical parameters of plants[17] and the growth of crop plants[18]. The ecology of reservoirs is under stressed condition due to the fast pace of development, deforestation, cultural practices and agriculture. These activities trigger the rate of sedimentation of the reservoir bed characterised by silt and organic suspended material which initiates the process of eutrophication at a very early stage and show a deterioration of habitat quality. It has become necessary to pay proper attention to find out the extent of possibilities of impounded water for raising the fishery wealth. Productivity of the reservoir is greatly influenced by its morphometric and hydrological features[19]. Increasing industrialisation, urbanisation and developmental activities associated with population explosion have brought inevitable water crisis[20]. Algae are recommended for monitoring water quality[21]. Some workers have shown that organic matter played an important role in the fluctuations of blue-green algae[22,23].

Pollution studies on streams or major rivers have been taken up by many workers at lower stretches including Kanpur, Allahabad, Lucknow, Varanasi, Delhi, Bhagalpur, Patna and Kolkata. However, no substantive work has been done so far on the lower stretches of streams or rivers except some fragmentary reports which are available on the pollution study of Ganges at Haridwar. But no work has been reported on the pollution contributed by the industrial effluents. Therefore, it was felt necessary to study the impact of industrial effluents on the water quality of the Asan river at Doon Valley with the objectives: (i) Analysis of various physico-chemical and environmental variables (temperature, conductivity, turbidity, total dissolved solids, pH, dissolved oxygen, free CO_2, total alkalinity, nitrates, phosphates, BOD, etc.) of river water, (ii) Abundance and diversity of organism dwelling surface water, (iii) Identification of natural and anthropogenic factors influencing the aquatic biodiversity of the river Asan, and (iv) Conservation and management of aquatic biodiversity of river water.

EXPERIMENTAL

Materials and methods

The study area

Doon valley is an intermontane valley located within Siwalik foreland basin in Garhwal Himalaya. It is 80 km in length and 20 km in width with Siwalik range to its south and Mussoorrie range to north. The Doon is really composed of two valleys: the one sloping down to the Yamuna on the north-west, and the other, to the Ganges on the south-east. Their north-east and south-west N-E and S-W are the Himalayan Mountains and Siwalik hills, respectively. Their united area is about 673 sq miles, and they lie between $30^0 – 30^0$ 32’ N latitude, 77^0 43’ – 78^0 24’ E longitude. The whole area may be roughly described as a parallelogram 45 miles long from the north-west to south-west, and 15 miles broad in north-east to south-west direction.

The river Asan is one of the most-important river draining Doon valley. It is the main tributary of the Yamuna, and originates from the southern slopes of the spring of heads of Mussoorie range. Asan arc is located at 2121 ft above the sea, and when it joins the Yamuna, it is at 652 ft elevation. It receives only one tributary worth noticing; The tons which arises in the southern slopes of the Mussoorie range, west of Rajpur, joins the Asan a few miles beyond Bheem Tal. During the dry season, it has no water in its lower part.

Two sampling sites (S_1 and S_2) were selected covering the entire area at Doon valley. Special consideration was given to the source of pollution during identification of sampling sites, which is as follows:

(i) **Reference site (S_1)**: This is the point just before the river enters Pharma city, which is 5 km upstream from the S_2 and is located at Jhajra.

(ii) **Impacted site (S_2)**: This site is located at Selaqui near the industries of pharmaceuticals, textile, leather and polythene product etc. and is thinly populated township. This site receives effluents from the industries.

Climate

As study area is located in a valley on the river side, it experiences severe cold in winter, very hot and dry in summer and humid in monsoons.

Analysis of physico–chemical parameters

Water samples were collected from both the sampling sites (S_1 and S_2) in plastic bottles of one litre capacity. Physico-chemical parameters of the river water were determined following standard methods outlined in Welch[24] and APHA[25]. Some of the physico-chemical parameters such as temperature and pH were determined at the spot immediately after sampling, while other parameters i.e, total dissolved solids, hardness, conductivity, turbidity, chlorides, nitrate, phosphate, sulphate, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand and free carbon dioxide, were analyzed at the laboratory of the Department of Environmental Sciences, HNB Garhwal University, Srinagar-Garhwal.

Collection of aquatic flora and fauna

The aquatic fauna was collected from the river water at both the sites which were identified with the help of existing literature and their list was prepared. Insects inhabiting the shallow areas of the streams below stones were collected by enclosing $1 m^2$ of the substratum with fine square mesh netting cloth and sweeping the area completely. The insects were collected in cloth and picked up. The collected organisms were preserved in 4% formalin and identified.

RESULTS AND DISCUSSION

Source of pollution

The industries in Selaqui were started in 2001 and now they are generating about 360 million litres of effluents per day. Approx 70-80% of effluents are discharged into the Asan river. These effluents are not only rich in nutrients but also have many toxic materials which are hazardous to man and aquatic biota and agroecosystem. The major industries draining effluents into the Asan river include packaging, engineering and footwear companies releasing mainly tannins, phenols, acids and packing wastes.

Alteration of physico-chemical parameters

The changes in the physico-chemical characters have been given in Tables 1, 2 and 3. Turbidity and conductivity have increased in the water of the impacted site, but the pH has been reduced but it is on the lower side of the basic values. The values of water temperature have not shown remarkable change. There was remarkable increase in the concentration of free CO_2, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), chlorides, sulphates, nitrates, phosphates and total hardness (TH). The values of dissolved oxygen (DO) have decreased in the impacted site due to effluents released into the river water.

Alteration of biological parameters

Aquatic biodiversity of surface water is represented by planktonic organisms (phytoplankton and zooplankton), benthic organisms (macrozoobenthos), aquatic macrophytes and nektons (fish). Only a few species of Chlorophyceae and Bacillariphyceae have not been observed in the impacted site of the river, but Cynophyceae, Eugleniaceae and Xanthophyceae have been observed mainly in the impacted site of the river, which clearly indicate the pollution as these species are regarded as the pollution indicators (Table 4).

Many species of macro-invertebrates have not been observed in the impacted site (Table 5), but in case of fishes, only two species *Puntius ticto* and *Barilius vagra* were not found in the impacted site (Table 6).

Table 1: Impact of industrial effluents on temperature, turbidity, conductivity and pH of Asan river water during the period September 2006 to February 2007

Month	Air Temp. (°C)		Water Temp (°C)		Turbidity (NTU)		Conductivity (μ S cm^{-1})		pH	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
September	28.0	28.2	22.0	22.2	12	16	0.234	0.827	7.44	7.80
October	26.0	26.4	21.2	21.5	10	13	0.221	0.834	7.50	7.31
November	23.0	24.0	21.0	21.2	8	11	0.219	0.751	7.59	7.21
December	12.2	12.4	10.1	10.0	7	10	0.215	0.632	7.65	7.15
January	11.0	11.0	8.0	9.2	5	8	0.204	0.651	7.75	7.10
February	12.1	11.3	10.3	10.1	4	7	0.205	0.625	7.78	7.10

Table 2: Impact of industrial effluents on free CO_2, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS) of Asan river water during the period September 2006 to February 2007

Month	Free CO_2 ($mg\ L^{-1}$)		DO ($mg\ L^{-1}$)		BOD ($mg\ L^{-1}$)		COD ($mg\ L^{-1}$)		TDS ($mg\ L^{-1}$)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
September	2.2	12.2	3.5	2.2	1.78	78.02	18.350	144.720	820.20	880.50
October	1.4	11.1	5.8	2.8	2.03	127.42	19.200	198.210	325.70	425.60
November	0.6	10.4	7.4	2.9	3.71	124.16	19.220	234.210	65.90	150.90
December	0.5	10.3	7.8	2.7	3.94	124.13	19.500	223.240	46.10	165.90
January	0.6	8.4	9.5	3.2	3.98	130.32	20.410	228.150	39.20	105.50
February	0.7	10.3	9.2	3.0	4.1	135.24	21.420	228.240	45.25	120.65

Table 3: Impact of industrial effluents on chlorides, sulphates, nitrate, phosphates and total hardness of Asan river water during the period September 2006 to February 2007

Month	Chlorides ($mg\ L^{-1}$)		Sulphates ($mg\ L^{-1}$)		Nitrate ($mg\ L^{-1}$)		Phosphates ($mg\ L^{-1}$)		Total Hardness ($mg\ L^{-1}$)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
September	4.55	60.15	2.05	20.25	0.045	1.325	0.09	1.03	72.25	80.75
October	4.75	80.65	2.35	21.45	0.047	1.22	0.12	1.23	78.95	90.5
November	4.95	82.51	2.75	25.75	0.075	1.225	0.15	1.43	88.65	100.05
December	5.05	85.3	3	27.15	0.095	1.219	0.16	1.72	95.95	115.12
January	5.15	87.43	3.5	27.5	0.095	1.211	0.17	1.91	92.45	125.25
February	4.58	85.52	4.05	30.5	0.085	1.105	0.19	2.00	120.42	145.25

Table 4. Presence of phytoplankton/ periphyton recorded at different sampling sites in Asan river.

S. No.	Phytoplankton/ Periphyton	S_1 (Reference site)	S_2 (Impacted site)
	A. Chlorophyceae		
1	*Chlamydomonas*	+	+
2	*Chlorella vulgaris*	+	+
3	*Chladophora*	+	+
4	*Spirogyra*	+	-
5	*Ulotrhix*	+	-
6	*Volvox*	+	-
	B. Bacillariophyceae		
1	*Acanthes*	+	-
2	*Amphora*	+	-
3	*Cyclotella*	+	+
4	*Cymbella lata*	-	+
5	*Diatoma*	+	-
6	*Fragilaria*	+	+
7	*Hantzschia*	+	-
8	*Navicula*	+	+
9	*Nitzschia*	-	+
10	*Rhoicosphenia*	+	-
11	*Synedra*	+	+
12	*Tabellaria*	-	+
	C. Cynophyceae		
1	*Anabena*	+	+
2	*Phormidium*	-	+

Cont…

S. No.	Phytoplankton/ Periphyton	S_1 (Reference site)	S_2 (Impacted site)
3	*Oscillatoria*	-	+
	D. Eugleniaceae		
1	*Euglena*	-	+
	E. Xanthophyceae		
1	*Vaucheria*	-	+
	Total genera	**16**	**14**

+ Present ; – Absent

Table 5. Presence of macro-invertebrates in Asan river

S. No.	Macro-invertebrate	S_1 (Reference site)	S_2 (Impacted site)
	A. Annelida		
	Order: Hirudinaria		
1	*Hirudo medicinalis*	+	-
	B. Arthropoda		
	a. Order: Trichoptera		
1	*Hydropsyche*	+	+
2	*Plannaria*	+	-
3	*Molanna*	+	+
4	*Hydroptila*	+	-
	b. Order: Coleoptera		
1	*Psephenidae*	+	+
2	*Amphizoa*	+	+
3	*Anchycetus*	+	-

Cont…

S. No.	Macro-invertebrate	S_1 (Reference site)	S_2 (Impacted site)
	c. Order: Ephemeroptera		
1	*Baetis*	+	-
2	*Heptagenia*	+	+
3	*Ephemerella*	-	-
	d. Order: Diptera		
1	*Tendipes*	+	+
	e. Order: Crustacea		
1	*Cancer magister*	+	-
2	*Astacus fluviatilus*	+	+
	C. Mollusca		
	a. Order: Mesogastropoda		
1	*Campelona*	+	+
	TOTAL	**14**	**8**

Table 6. Fish alteration in Asan river.

S. No.	Fish (Scientific name)	Vernacular name	S_1 (Reference site)	S_2 (Impacted site)
1.	*Puntius ticto*	Patto	+	+
2.	*Tor chilinoides*	Kali Machhi	+	+
3.	*Chana punctatus*	Sewal	+	+
4.	*Mastecembalus armatus*	Baan	+	+
5.	*Barilius vagra*	Chaal	+	-
	TOTAL		**05**	**04**

In the present study, most of the physico-chemical characteristics of water of the impacted site have been changed. Steady change in the atmospheric temperature with the change in the seasons results in the corresponding change in the water temperature. There was a little change in the water temperature of the impacted site (S_2) in comparison to the reference site (S_1). Values of coefficient of correlation among the various physico-chemical parameters of water recorded at sites S_1 and S_2 of Asan river during the period September 2006-February 2007 have been given in Tables 7 and 8.

Conductivity reflects the amount of total soluble salts in water. It indicates the nutrient status of the water and distribution of macrophytes. Higher value of conductivity was recorded on site S_2 which indicated the higher nutrient level on this site. Lower value on site S_1 might be due to the presence of macrophytes which can absorb ions and reduce the conductivity level. Phytoplanktons of the water bodies are subjected to strong monthly influences. In tropical climates, there is great contrast between rainy and winter months. Phytoplanktons respond to constant rearrangement of physical and chemical structure of their environment with characterisitic population fluctuation[26]. In the present investigation, the value of conductivity was highest in September and lowest in February. Conductivity is positively related with temperature, but it has shown negative correlationship with dissolved oxygen. Conductivity has shown positive relationship with pH, free carbon dioxide and total dissolved solids (Tables 7 and 8).

The turbidity of water is mainly attributed to the total solids (suspended and dissolved) present in the river including microscopic organisms. The values of turbidity in the present study were low on site S_1. Many workers have also reported high turbidity during monsoon period and low during summer and winter[27,28]. Turbidity has shown positive relationship with conductivity, pH, free carbon dioxide and total dissolved solids. Bhatt and Negi[29] observed low turbidity during November-February and an increase after May reached peak in August in river Kosi. They attributed that during monsoons, the river water contained large amount of silt, fine sand particles, organic matter and clay.

Table 7. Coefficient of correlation among the various physico-chemical parameters of water recorded at Site S_1 of Asan river during the period September 2006-February 2007

	AT	WT	TUB	CON	pH	FCO_2	DO	BOD	COD	TDS	Cl	SO_4	NO_3	PO_4	TH
AT	1														
WT	0.9847	1													
TUB	0.9195	0.8659	1												
CON	0.8929	0.8549	0.9736	1											
pH	-0.938	-0.8963	-0.9957	-0.9657	1										
FCO_2	0.8019	0.6994	0.8592	0.8518	-0.8285	1									
DO	-0.8962	-0.8329	-0.9766	-0.9803	0.9643	-0.9289	1								
BOD	-0.8817	-0.7915	-0.9161	-0.8468	0.9092	-0.9354	0.9267	1							
COD	-0.805	-0.7731	-0.9398	-0.9219	0.9336	-0.6736	0.8701	0.7402	1						
TDS	0.7694	0.6658	0.8574	0.8669	-0.8189	0.9914	-0.9292	-0.9292	-0.7025	1					
Cl	-0.5053	-0.4735	-0.3837	-0.4593	0.3839	-0.6798	0.5476	0.5476	0.085	-0.6342	1				
SO_4	-0.8845	-0.8416	-0.9807	-0.9354	0.9815	-0.7541	0.9176	0.9176	0.9765	-0.7567	0.2039	1			
NO_3	-0.9431	-0.8892	-0.8744	-0.8269	0.8848	-0.8933	0.8936	0.8936	0.6691	-0.8398	0.6707	0.7977	1		
PO_4	-0.8948	-0.8175	-0.9861	-0.9481	0.9702	-0.9109	0.9733	0.9733	0.9073	-0.9107	0.3979	0.9556	0.8812	1	
TH	-0.7845	-0.7154	0.896	-0.8066	0.8824	-0.6971	0.8032	0.8032	0.9247	-0.7068	0.0052	0.941	0.7001	0.9117	1

AT-Air Temperature, WT-Water Temperature,TUB-Turbidity, CON-Conductivity, FCO_2-Free CO_2, DO-Dissolved Oxygen, BOD-Biological Oxygen Demand, COD-Chemical Oxygen Demand, TDS-Total Dissolved Solids, Cl-Chloride, SO_4- Sulphate, NO_3- Nitrate, PO_4- Phosphate, TH-Total Hardness

Table 8. Coefficient of correlation among the various physico-chemical parameters of water recorded at Site S_2 of Asan river during the period September 2006-February 2007

	AT	WT	TUB	CON	pH	FCO_2	DO	BOD	COD	TDS	Cl	SO_4	NO_3	PO_4	TH
AT	1														
WT	0.9919	1													
TUB	0.9059	0.85	1												
CON	0.9758	0.9535	0.8964	1											
pH	0.7659	0.6985	0.9139	0.7549	1										
FCO_2	0.774	0.7376	0.8227	0.7091	0.8064	1									
DO	-0.6566	-0.5859	-0.8689	-0.5994	-0.9087	-0.8928	1								
BOD	-0.6314	-0.5616	-0.8403	-0.5957	-0.9657	-0.7109	0.9081	1							
COD	-0.6771	-0.5893	-0.8693	-0.7095	-0.9698	-0.7722	0.8806	0.9166	1						
TDS	0.7556	0.6777	0.9128	0.7742	0.9853	0.8149	-0.8948	-0.9819	-0.9931	1					
Cl	-0.7319	-0.6686	-0.8777	-0.7075	-0.9949	-0.8091	0.9096	0.9719	0.9569	-0.971	1				
SO_4	-0.8996	-0.8412	-0.9632	-0.9209	-0.8345	-0.6979	0.7258	0.7243	0.8218	-0.8613	0.7781	1			
NO_3	0.6883	0.6242	0.8151	0.6815	0.8219	0.5065	-0.7494	-0.8548	-0.7577	0.781	-0.7847	-0.8442	1		
PO_4	-0.9667	-0.9305	-0.9815	-0.9519	-0.8493	-0.8078	0.7849	0.7851	0.7851	-0.8463	0.8091	0.9629	-0.8178	1	
TH	-0.9193	-0.8814	-0.9577	-0.9114	-0.7805	-0.6817	0.7199	0.7099	0.7099	-0.7704	0.7279	0.9606	-0.8822	0.9745	1

AT-Air Temperature, WT-Water Temperature,TUB-Turbidity, CON-Conductivity, FCO_2-Free CO_2, DO-Dissolved Oxygen, BOD-Biological Oxygen Demand, COD-Chemical Oxygen Demand, TDS-Total Dissolved Solids, Cl-Chloride, SO_4- Sulphate, NO_3- Nitrate, PO_4- Phosphate, TH - Total Hardness

It is well established that the pH of the natural water is controlled to a greater extent by the interaction of hydrogen ions resulting from the dissociation of carbonic acid and from hydroxyl ions arising from the hydrolysis of bicarbonates. The values of pH were low on S_2.

Dissolved oxygen (DO) is a very important parameter of water quality and an index of physical and biological process going on in water. Significantly lower DO can be attributed to the low phytoplankton concentration in water. According to Banerjea[30], dissolved oxygen concentration below 5 ppm may be considered unfavourable for production of fish and that above 7 ppm was suitable for fish production and the fluctuation to DO did not show any seasonal trend. But in the present study, the DO concentration was highest in January and lowest in September, but the values decreased on site S_2 in comparison to site S_1.

In different Indian rivers, various workers have reported different types of trends in maximum and minimum concentrations of dissolved oxygen[28]. In the present study, the DO level was lower, which does not indicate a good condition for the growth of fishes and plankton populations. Free carbon dioxide increased in the impacted site due to pollutants.

The chemical oxygen demand (COD) is a measure of pollution in aquatic ecosystems. It estimates carbonaceous factor of organic matter. The permissible upper limits to COD for drinking and irrigation water are 20 and 150 mg/L, respectively. Highest value of COD was observed in February and lowest in September. The chemical oxygen demand (COD) represents chemically oxidizable load of organic matter in water. The range of values of COD in the present study are comparable to the values reported for many Indian rivers compiled by Sabata and Nayar[28], but the values increased in the impacted site. The values of COD were positively related with hardness and negatively related with TDS (Tables 7 and 8). In the present study, the value of BOD was highest in February and lowest in September with increased values on impacted site (S_2).

Chloride is one of the important indicators of pollution. Datta *et al.*[31] have shown that the chlorides occur naturally in all types of waters and high concentration of chlorides is considered to be the indicator of pollution due to high organic waste of animals. Chloride showed lowest value in September and highest in February. The values showed positive relationship with sulphates and hardness.

The nitrate values increased in September and lowest was recorded in February. The increased value may be due to the higher phytoplanktonic production, decaying macrophytes and concentration of nutrients owing to the evaporation of reservoir water with subsequent increase in nitrate value. Decrease in nitrate content during winter months was probably due to its utilization as nutrient by the algal community as evidenced by the luxuriant growth of algae particularly in the winter months. The values of nitrates in the present study are comparable to the values reported for different rivers of India[32].

Phosphates are essential for the growth of algae, but are usually present in low concentrations in natural unpolluted rivers. Phosphate fluctuations in Indian rivers were mainly attributed to planktonic productivity[33, 34].

In the present study, pollutants affected the presence of many algae, which increased showing the impact of pollution. Similarly, aquatic invertebrates and fishes also showed change in their populations. Such studies have also been conducted in different rivers of India.

CONCLUSION

The study has found enormous changes and deterioration in the quality of water of Asan river due to the discharge of effluents into the river. The results urgently call for the formation of a balanced policy for preventing the discharge of effluents into the river water so that the quality of river water is maintained and the aquatic life is saved.

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