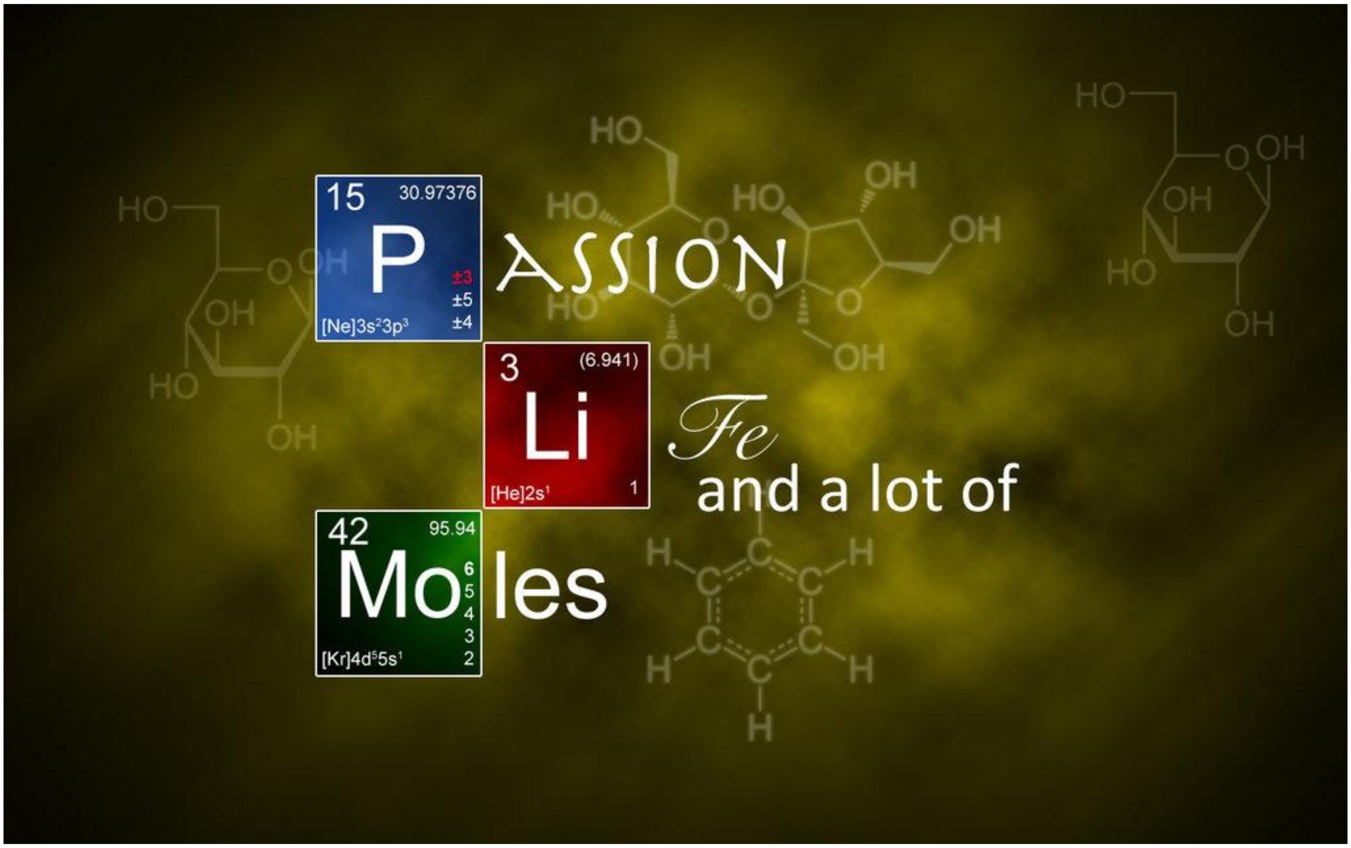

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Evaluation of Physicochemical Parameters of River Hndon Using Water Quality Index At Muzzaffarnagar, U.P, India

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ABSTRACT

The physicochemical studies of Hindon river water at Muzzafarnagar district, UP, India, have been carried out. It has been shown that the quality of surface water was affected due to industrial activity going on in the region. Water samples of three sampling stations namely SI (Anechh, Charthawal), SII (Titawi) and SIII (BHL Budhana) have been taken for seasonal investigation and to assess the level of quality and pollution in the river. Physicochemical and bactrological parameters such as pH, Conductivity, Turbidity, TDS, TSS, TS, BOD, COD, Total Hardness, Ca, Mg, Phosphate, Nitrate, Alkalinity and Total Coliform density were studied as per WHO water quality standards. Further water quality of river Hindon has been assessed using water quality index and the quality of river Hindon was observed to be bad at all site which may be attributed to untreated / partially treated waste west materials of municipal and industrial effluents joining the river. The water samples were collected and analysed during Pre-monsoon (March to May), Monsoon (June to September) and Post-monsoon period (October to February) in 2012. It has been found that these water samples have very high conductivity, turbidity, BOD, TSS, alkalinity and also highly bactrologically contaminated.

Key words: water quality, Hindon river, pollution, industrial effluent, contamination

1. INTRODUCTION

River Hindon, a tributary of river Yamuna and grand tributary of holy Ganga is flowing through six districts of Western Uttar Pradesh including Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautambudh Nagar. It is one of the main tributaries of Yamuna in plain including Chambal, Sindh, Betwa and Ken while Rishi Ganga, Hanuman Ganga, Tons and Giri are in the Himalayan region. It flows in between Ganga and Yamuna and holds the position in the east and west respectively. This river holds a historical identity for being the lifeline [1-3] of the people of western UP and considered as a symbol of curing from Kaali Khansi (bad cough). Today the river is all most dead, become rainfed and having zero dissolved oxygen level [4, 5] throughout the length of this river resulting non existence of fish and biodiversity.

River or tributary of a holy river holds the credit for playing important role in maintaining the river ecology of the region, cultural significance for the local people and supporting in numerable living species and human being [6, 7]. Most of the cities get a large part of drinking water from river. It has been well recognized that the origin of almost all ancient civilizations developed on the banks of rivers. The river water has been generally used for irrigation, drinking and industries as well as for mass bathing, laundry, cattle bathing, and secretion of the cremation ash. These days the inflow of wastewater either treated or partially treated in the river further aggravates the water quality problem [8, 9] of the river. Hindon has become a drain [10, 11] due to widespread discharge of sewage and effluents from municipal colonies and industries. It is essential to create some awareness among people and way to check the river pollution and to save the life line of the people. There is a heavy load of heavy metals like lead, chromium, and cadmium in the river water apart from deadly pesticides [12] like Heptachlor, Heptachlor Epoxide, Fipronil, Eldrin, Endosulphan-I & II and BHC-y etc. These facts have been recently reported in a study of Hindon River water quality. The samples collected from different location points of different district have revealed presence of lead which is 35 times more than the permissible limit and Chromium [13, 14] is 19 times more than the permissible limit. Large number of farmers on both sides of the river use this contaminated water for irrigation purpose which has also leached into the aquifers. The domestic cattle is also facing serious digestive problems. Further, the toxic pollutants from these sources will ultimately reach the ground water and enter in the food chain posing a threat to human health because of their carcinogenic nature.

Thousands of patients are suffering from cancer, neurological disorders, stomach ailments and serious skin diseases which are directly linked to the alarming levels of heavy metals and pesticides in the river. Presence of even the internationally banned pesticides called persistent Organic Pollutants should be a matter of severe concern for everyone. There are about 500 mightiest rivers in the world. More than half of them have been seriously depleted [15]. Drying or dying up of rivers is grate alarm to the society for devastating consequences for humanity, animals and the future of the planet. 40% of American rivers are highly polluted even for fishing, swimming or aquatic life.

The Hindon river is a considerable source of water to the highly populated rural area of western Uttar Pradesh. It irrigates a large area of agricultural land and is mainly used for procuring the fish and fish seed.

The heavy loading of industrial effluent discharge directly into the Hindon River places an intolerable burden on the river's natural ability to assimilate pollutants. The main sources of pollution in River Hindon include municipal and industrial (sugar, pulp and paper, distilleries etc.) wastes from Saharanpur, Muzaffarnagar and Ghaziabad urban areas. The water quality of the River Hindon gets further deteriorated due to confluence of River Kali and River Krishni [16, 17] as these rivers receive toxic effluents from different industries. However it lies in Haryana nearly 7-17 km and in Uttar Pradesh nearly 47-1000 km. Hindon, a perennial river of a time has now become a toxic streams or drain with seasonal flow in most of its reaches. A number of paper manufacturing unit, Sugar Plant, distilleries, dairy, textile units and Slaughter houses have been set up all along its length. These industries not only exploit large amounts of water from river but also discharge their effluents directly into the river, often with very normal or no treatment. These effluent, chemical pollutants and domestic sewerage contribute significantly to the contamination of its water. The physical and biological disorderness [18, 19] in living being are seen due to intake of contaminated water. So, there is urgent need to monitor the water quality of Hindon river with view to its fitness for human consumption and to declare the status of pollution, suitability for consumption and for industrial use. In this paper, the physico-chemical microbiological investigation parameters analysed and monitored for the study of water samples of selected three sampling stations namely SI (Anechh, Charthawal), SII (Titawi) and SIII (BHL Budhana) and their up and down streams at 500 meter include pH, Conductivity, Turbidity, Total Dissolved Solids(TDS), Total Suspended Solid (TSS), Total Solid (TS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Hardness, Ca, Mg, Alkalinity, Phosphate, Nitrate and Coliform density. In addition water quality index (WQI) has been adopted for measuring the water quality. WQI holds a potential worth to assess the level of pollution and allows for comparisons to be made between different rivers. This index allows for a general analysis of water quality on many levels that affect a huge ability to host life. The index result represents the level of water quality in a giver water basin, such as lake, river or stream. A number of workers all over the world developed [20, 21] WQI based on rating of different water quality parameters. Basically a WQI attempts to provide a mechanism for presenting a cumulatively derived, numerical expression defining a certain level of water quality for the evaluation of water quality, WQI was applied to river water. Atleast 30 water quality indices are being used over the world, with the number of variables ranging from 3 upto 72.

Study Area

The Hindon River or Haranandi is one of the tributaries of river Yamuna and flows along the western districts of Uttar Predesh and Uttarakhand. The river lies between the latitudes 28°4′′ N and 30°5′′ N and longitudes 77°5′′ E and 77°9′′ E. The Hindon River originates from Purka Tanka village located in the lower Himalayas in Saharanpur district. After passing through Saharanpur, Muzzafarnagar, Bagpat, Meerut and Gaziabad, Hindon merges with the Yamuna at Maviwara (Tilwara village). The Hindon River drains a catchment of approximately 5000 km^2 of largely agricultural land while flowing through a number of substantial sized towns and villages. The study area of present investigation lies between the latitude 29.4723^{0}N and longitude 77.7089^{0}E and the sites belong to the villages namely SI (Anechh, Charthawal), SII (Titawi) and SIII (BHL Budhana) of Muzaffarnagar district, UP, India. The figure of the sampling sites and river Hindon has been shown in figure 1.

FIGURE 1: LOCATION MAP OF SAMPLING STATIONS OF HINDON RIVER AT MUZZAFFARNAGAR DISTRICT

2. Materials and methods

For physico-chemical and bactrological investigation of river water, the samples of Muzaffarnagar district, UP, India, from three sampling stations/sites namely SI (Anechh, Charthawal), SII (Titawi) and SIII (BHL Budhana) were collected and analyzed as per the standard methods [22, 23]. A total of 27 samples including 500 m up and down streams off all three sites were collected in pre-monsoon, monsoon and post-monsoon season. All the samples were collecting in polypropylene bottles. Before collecting the samples, bottles were through cleaned by 8M HNO_3, followed by repeated washing with deionized water. Total hardness (TH) and Alkalinity of the samples were determined by titration method. The analysis of magnesium and calcium were determined by the method of titration. The pH, Electrical conductivity (EC) and Turbidity were measured with the help of recalibrated portable pH meter, conductivity meter and Nephelo meter respectively. For determination of Nitrate (NO_3) and Phosphate (PO_4) UV-VIS spectrophotometer (Hitachi 3210) was used.

3. Results and discussion

The physico-chemical characteristics[11] of water samples of three different sampling stations (S-I, S-II & S-III) of the river, selected on the basis of the magnitudes of activities and disturbances, show marked seasonal variation which is reported in Table 1.

pH

The pH of the water samples S-I, S-II and S-III has been found in the range of 7.68 to 8.09 during pre-monsoon, monsoon and post-monsoon period. The maximum value of pH of water samples was in pre-monsoon period for S-1. The average pH value was 7.8. The variation of pH with different sampling sites is shown in fig 2. No significant change in pH occurs even existing of effluent disposal. This may be due to releasing of properly treated industrial effluent and put it up far from the sampling stations.

Electrical Conductivity

The ionic form of salts and other contaminants in waste water increases the conductivity of water. It is good and rapid measure of total dissolved solid. Generally, it has been found that the dissolve solids are more than 65% of the conductivity of water. The electrical conductivity (EC) of the water samples has been found in the range of 1232 to 1548mmhos/cm. WHO guideline infers the tolerance limit is 0.4 mmhos/cm for drinking water. The EC level of all water samples of the river is beyond the limits prescribed by WHO and CPCB. The average value of EC is 1343. Fig. 3 shows a very high EC level 1548mmohs/cm for S-I in post-monsoon period. The increasing trend in EC level is probably due to release of effluents of the factory and the decreasing trend is due to the dilution [24] over a stretch for the river.

Turbidity

Organic matters, clay, phytoplankton and other microorganisms create turbidity in water and make it unfit for drinking purposes and for food and beverage industries. Turbidity of water samples of S-I, S-II and S-III during the studied period has been found in the range of 8 to 15, 7 to 10 and 12 to 15 NTU, respectively. The minimum value recorded is 7 NTU for S-I during monsoon while maximum value recorded is 15 NTU for S-II during pre- monsoon and post-monsoon period. The average turbidity was 11.22. Turbidity of 100% samples (Fig. 4) was found to be above the permissible limit 5 NTU. It has been inferred that over permissible limit it plays several effect on cardiovascular disease[13].

Total Solid

High level of total solids (TS) is aesthetically unfit and may cause distress in humans, stomach upset, fiver and livestock. The values obtained for all sites are nearly same in monsoon season. The variation of TS with different sampling sites is shown in fig. 5. The amount of total solids includes both Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) was observed maximum 1076 mg/L with a average value of 9.12 in all the water samples. The presence of such materials causes the water turbid and clog and the pores of the soils causing temporary submergence. TS in the water samples of the study area S-I, S-II and S-III was in between 706 to 793 mg/L in monsoon and 778to 1076 mg/L on post-monsoon season respectively. Overall the TS for all the sampling sites and in all the seasons have been found below the permissible limit of 1500 mg/L.

TSS

The value of TSS measured was found in between 48 to 247 mg/L while the average value was 122.2 mg/L. For S-II, the value is maximum (Fig. 6) for all seasonal periods. TSS value less than 200 mg/L and greater than 30 mg/L suggest that the standard of water is as per that of pond water. It is not recommended for drinking purposes but it could be use for irrigation.

Total Dissolve Solids

The various kinds of minerals and soluble and ionizable inorganic salts are responsible for the presence of total dissolved solids (TDS) in water separated from suspended solids using a filter of 2.0 μm pore size. Calcium, magnesium, sodium, bicarbonates, chlorides and sulphates are the major constituents for existing TDS in water. TDS on the whole affect the test of drinking water quality. The palatability of water with a TDS level less than 600 mg/L is generally considered. Observed values are in the range of 712 to 877 mg/L (Fig. 7). During post-monsoon period TDS was found maximum in all sites. In the study TDS of 100% of water samples are found below the permissible limit (1000 mg/L) for drinking purposes.

Alkalinity

It gives information of aggregate property of water which is very helpful in deciding the mode of treatment of water. Water becomes alkaline due to carbonates, bicarbonates, hydroxide ions and salts of weak acid and strong base. The total alkalinity due to carbonate and bicarbonate is always less than the total hardness. The average value of alkalinity was found 132.44. Table 1 infers the alkalinity lies between 241 to 312 mg/L which is beyond the permissible limit 100 mg/L and shown in Fig. 8. . During post-monsoon period Alkalinity was found maximum in all sites.

Total Hardness

Total hardness of water has been recognized due to presence of salts of Ca, Mg, Sr, Fe, Mn, Al with anions, carbonates, bicarbonates, chloride sulphate, nitrate, and silicate. Temporary hardness shows the presence of bicarbonate of Ca and Mg while permanent hardness consist the presence of chloride and sulphate of the same element. Amount of hardness which is more than carbonate hardness is called non-carbonate hardness. Total hardness is expressed in terms of calcium carbonate in mg/L or ppm. The variations of TH at different sampling stations in different seasons have been shown in fig. 9. The value of total hardness was found in range of 372 to 521 mg/L in pre-monsoon period, 358 to 498 mg/L in monsoon season and 547 to 612 mg/L in post-monsoon season while the average value of TH was found 470 mg/L. The values are less than the permissible limit of 500 mg/L in all the seasons. Low value of hardness in monsoon season is mainly due to the excess water availability in the river.

Calcium

It has very significant role for nervous system and in formation of bones and teeth. Excess calcium intake causes hypercalcimiya disease [25] in form of stone, stork, arthritics, and hypertension whereas deficiency of calcium causes osteoporosis diseases such as rickets, dryness, skin diseases etc. In this study calcium concentration of water sample varied from 64 to 94 mg/L. The minimum concentration has been found in monsoon for S-II. These concentrations are shown below the permissible limit 100 mg/L.

Magnesium

Its content in water samples was found in the range of 38 to 76 mg/L, which is beyond the permissible limit 50 mg/L recommended for potable water for the S-I in all seasons and during pre-monsoon period all the sites posses above range than permissible limit. The minimum value was seen in monsoon and post-monsoon for the sites S-I and S-II. Higher concentration of magnesium may cause cathartic and diuretic for user. The variation of Ca and Mg content with different sampling stations are given in figure 10 & 11.

BOD and COD

Dissolved Oxygen (DO) for all three sites of Hindon river has been found zero during pre-monsoon, monsoon and post-monsoon period. Biochemical Oxygen Demand (BOD) refers the ability and strength of organic matter which is responsible to decrease oxygen in water. The amount of oxygen required for oxidation of organic material by bacterial action in presence of oxygen. It occurs due to microorganism so generally gives qualitative index of organic substances which are degraded quickly in a short period of time. The BOD level for all three sites has been found in the range of 27.9 to 124.6 mg/L. The recommended value of BOD is 20 mg/L for the waste water. The higher value of BOD than permissible limit has been found at all three sites and all three seasons. This may be due to the release of effluents of sugar mill/ distillery/ heavy organic waste load [26, 27] nearby the site. The variation of BOD level with different sampling stations is shown in fig. 12.

Chemical Oxygen Demand (COD) also decreases oxygen in water. It is the amount of oxygen required for oxidation of organic and oxidisable inorganic materials in water. Its value is more than BOD values. The variation of COD with different sampling stations is shown in fig. 13. The COD level of the given water samples have been found in the range of 185 to 678 mg/L during pre-monsoon, monsoon and post-monsoon period. The average value of COD is 375 mg/L, which are above the permissible limit 250 mg/L. The maximum COD level was observed in post-monsoon period for site S-I. This high COD level indicates the loading of heavy carbonaceous matter [28, 29] in the river watt.

Phosphate

Phosphate content(fig.14) in water sample was found in the range of 0.35 to 4.42 mg/L during pre-monsoon, monsoon and post-monsoon period, which is above its permissible limit 0.1 mg/L for drinking water. The maximum value was found in pre-monsoon period for S-III and this site holds higher value than the permissible limit in all seasions. It is due to interference of domestic sewage discharge of effluent, and human indulgences with water sources. The high level of phosphate indicates eutrophication growth [30, 31]. It is usually found in water sample as inorganic as well as organic form.

Nitrate

The nitrate content in the given water sample has been found in the range of 1.68 – 2.51 mg/L during pre-monsoon, monsoon and post-monsoon period, which is far below than the recommended value 45 mg/L of nitrate in drinking water. The source of nitrate holds biological oxidation of nitrogenous substances which come in sewage and industrial waste. It is very important water quality parameter for health and hygiene. It inters into water from fertilizer, decayed vegetables and animal domestic effluent, sewage sludge, farm leachiest. The variations of nitrate with different sampling sites are shown in Fig. 15. Very low content of nitrate indicates absence of contamination due to human and animal waste.

Total Coliform

The density of bacterial contamination/ pollution enforces water quality standard as well as traces the survival of microorganisms in the river. The most common microbiological examinations for water quality assessment are heterotrophic counts and total fecal coliform tests [32-34]. Total coliform test (TC) and heterophilic plate counts (HPC)/standard plate counts (SPC) are usually carried out for treated water whereas faecal coliform tests are performed on untreated water. The major source of contamination in river waters include untreated or poorly treated municipal and industrial effluents or sludge, drainage and sanitary water from residence, fecal wastes, storm water, runoff, and excretions from animals. In SPC procedure the number of heterotrophic bacteria is measured in colonies of chains, pairs, clusterings or single cells in colony forming units.

The most probable number (MPN) of the coliform density through multiple tube fermentation technique was measured. Table 1 suggests the coliform density; a criterion for pollution has been found greater than 1600 per 100 mL which is above than its permissible limit for all the sites and in all the seasons. Among 27 samples collected from different sites and in different seasons all of them were not safe for drinking as they contain coliform organism greater than 1600 MPN/100mL. It is further suggested the water is not fit for drinking and very hazardous for health.

The Standard Plate Counts (SPC) are carried out for the transmission of fecal/pathogenic microorganism such as staphylococous which affect skin, mouth or nose of bathers. The value has been found in the range of 82 to 380 per 100 ml, which is also higher (Fig. 16) than the recommended value.

Water Quality Index

Water quality index (WQI) was calculated for assessing the water quality of river Hindon at different sites in per- and post-monsoon seasons 2012. WQI of River Hindon was calculated as proposed by Tiwari and Mishra (20). It was done by considering eight important physicochemical properties using Central Public Health Environmental Enginneering Organisation (CPHEEO), 1991 and Indian Council of Medical Research (ICMR), 1975 standards. In order to calculate WQI eight Important parameters, pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), Total Alkalinity (Alk), Total hardness (Hard), calcium (Ca) and magnesium (Mg) were used. These parameters maximum contribute for the quality of river.WQI factors which have higher permissible limits are less harmful because they can harm quality of river water when they are present in very high quantity. The weightage factor of parameters has an inverse relationship with its permissible limits and is given by

$$W_i = k/X_i$$

where k is constant of proportionality, W_i is unit weight of various parameters and X_i is world by accepted water quality standard prescribed by WHO/EPA.

$$\sum_{1}^{8}\left(\frac{1}{Xi}\right) = \frac{1}{\mathrm{Xi(pH)}} + \frac{1}{\mathrm{Xi(DO)}} + \frac{1}{\mathrm{Xi(EC)}} + \frac{1}{\mathrm{Xi(TDS)}} + \frac{1}{\mathrm{Xi(Alk)}} + \frac{1}{\mathrm{Xi(Hard)}} + \frac{1}{\mathrm{Xi(Ca)}} + \frac{1}{\mathrm{Xi(Mg)}}$$

The weightage of all the factors were calculated on the basis of the above equation and given in Table-2.
The overall WQI is calculated by taking geometric mean of these sub indices given by

$WQI = \Sigma(X_r)^{Wn}$ where $X_r = 100\ X_i/X_s$

or WQI anti log $[\Sigma\ W_n \log X_r]$

Quality status is assigned on the basis of calculated values of water quality indices. Following assumptions are made in order to assess the extent of contamination or the quality of drinking water. WQI < 50: Fit for human consumption, WQ I < 80: Moderately contaminated, WQI > 80: Excessively contaminated, WQI > 100: Severally contaminated. Experimental result measures the WQI average value of Hindon river in Muzzafarnagar is 334 which suggests severally contaminated of river water.

Rating Scale

Physicochemical parameters are individually considered for a particular rating scale; X_r (Table-3) which has been taken a range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating $X_r = 0$ implies that the parameter present in water exceeds the standard maximum permissible limits and water is severely polluted. On the other had $X_r = 100$ implies that the parameter present in water has the most desirable value. The other ratings fall between these two extremes and are X_r=40 X_r =60 and X_r =80 standing (Table-4) for excessively polluted, moderately polluted and slightly less polluted (35) respectively. This scale is modified version of rating scale given by Tiwari and Mishra. Water quality indices for water quality at all three sites of river Hindon in pre, post and monsoon seasons were calculated in the light of Akkaraboyina and Raju, 2012 report [35] and It was found that the water quality of river Hindon at all three sites in all season was 40 which refers bad quality of water, may be due to untreated and /or partially treated waste inputs of municipal and industrial effluents joining the river.

Table 1: Physicochemical characteristics of Hindon river water at Muzaffarnagar District, UP

Parameter	WHO(2004)	Periods	Sites				Remarks
			I	II	III	Average	
pH	6.5 - 8.5	Pre-monsoon	8.09	7.93	7.68	7.9	
		Mosoon	7.56	7.84	7.69	7.696667	Slightly Basic
		Post-monsoon	7.69	7.8	7.89	7.793333	
Conductivity	0.40mhos/cm	Pre-monsoon	1369	1232	1428	1343	
		Mosoon	1289	1240	1147	1225.333	Very High
		Post-monsoon	1548	1478	1248	1424.667	
Turbidity	5 NTU	Pre-monsoon	8	15	11	11.33333	
		Mosoon	7	10	8	8.333333	High
		Post-monsoon	15	15	12	14	
TS	1500mg/L	Pre-monsoon	974	1024	956	984.6667	
		Mosoon	793	706	806	768.3333	Tolerable
		Post-monsoon	1076	959	778	937.6667	
TSS	30mg/L	Pre-monsoon	97	231	48	125.3333	
		Mosoon	81	158	48	95.66667	High
		Post-monsoon	98	247	89	144.6667	
TDS	1000mg/L	Pre-monsoon	877	793	908	859.3333	
		Mosoon	712	548	758	672.6667	Reasonable
		Post-monsoon	978	712	689	793	
Alkalinity	100mg/L	Pre-monsoon	283	275	271	276.3333	
		Mosoon	310	248	241	266.3333	High
		Post-monsoon	287	312	287	295.3333	
Total Hardness	500mg/L	Pre-monsoon	521	372	382	425	
		Mosoon	498	358	374	410	Tolerable
		Post-monsoon	612	547	569	576	
Ca	100mg/L	Premonsoon		88	68	72	76
		Mosoon	74	72	64	70	Reasonable
		Post-monsoon	89	94	81	88	
Mg	50mg/L	Pre-monsoon	76	51	51	59.33333	
		Mosoon	68	45	42	51.66667	Tolerable
		Post-monsoon	71	42	38	50.33333	
BOD	20mg/L	Pre-monsoon	92.4	31.5	48.3	57.4	
		Mosoon	78.4	27.9	41.6	49.3	High
		Post-monsoon	124.6	32.7	56.8	71.36667	
COD	250mg/L	Pre-monsoon	520	192	264	325.3333	

		Mosoon	470	185	215	290	Tolerable
		Post-monsoon	678	198	354	410	
Phosphate	0.1mg/L	Pre-monsoon	2.25	0.56	4.42	2.41	
		Mosoon	1.25	0.39	3.45	1.696667	High
		Post-monsoon	1.84	0.35	2.78	1.656667	
Nitrate	45mg/L	Pre-monsoon	2.03	2.51	2.43	2.323333	
		Mosoon	1.68	1.89	2.17	1.913333	Reasonable
		Post-monsoon	1.78	1.92	2.18	1.96	
Total Coliform	0	Pre-monsoon	>1600	>1600	920	#VALUE!	
		Mosoon	>1600	>1600	690	#VALUE!	Bad
		Post-monsoon	>1600	>1600	798	#VALUE!	
SPC	0	Pre-monsoon	380	200	108	229.3333	
		Mosoon	340	180	80	200	Bad
		Post-monsoon	340	180	80	200	

Table 2: WHO/EPA standards and assigned unit weights

Water Quality Factors	WHO/EPA Standards (X_i)	Unit Weight (W_i)
pH	8	0.3342
DO	5	0.5348
EC	300	0.0089
TDS	1500	0.0018
Alkalinity	100	0.0267
Total Hardness	600	0.0045
Ca	75	0.0356
Mg	50	0.0535

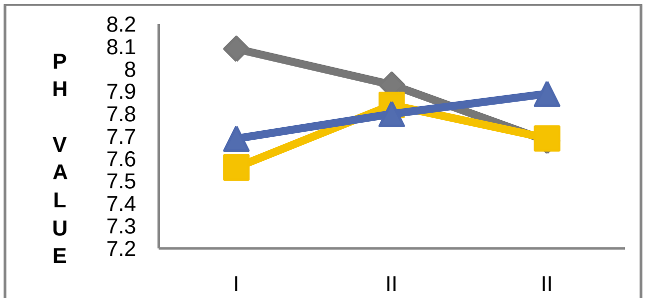
Table 3: Rating scale for calculating WQI

Water Quality parameter		Ranges			
pH	8	8.6 – 8.7	8.8 – 8.9	9.0 – 9.2	> 9.2
		6.8 – 6.9	6.7 – 6.8	6.5 – 6.7	< 6.5
DO	7	5.1 – 7.0	4.1 – 5.0	3.1 – 4.0	< 3.0
EC	100	75.1 -150	150.1- 225	225.1 - 300	> 300
TDS	500	375.1 -750	750.1 -1125	1125.1 - 1500	> 1500
Alkalinity	50	50.1 – 70	70.1 – 90	90.1 – 120	> 120
Total Hardness	100	150.1 - 300	300.1 - 450	450.1 - 600	> 600
Ca	25	20.1 – 40.0	40.1 – 60.0	60.1 – 75.0	> 75
Mg	15	12.6 – 25.0	25.1 – 37.5	37.6 - 50	> 50
X_r	100	80	60	40	0
Extent of pollution	Clean	Slight pollution	Moderate pollution	Excess pollution	Severe pollution

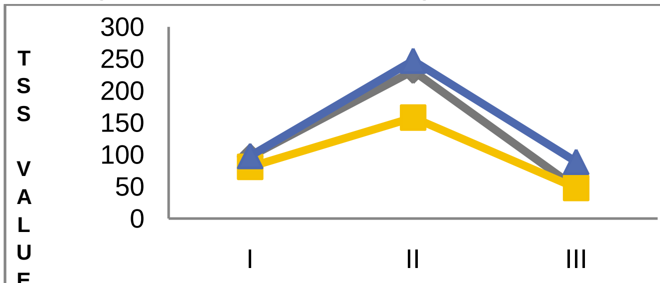
Table 4: Rating Scale for Quality of Water

Value of WQI	Quality of Water
90 -100	Excellent
70 – 90	Good
50 – 70	Medium
25 – 50	Bad
0 – 25	Very Bad

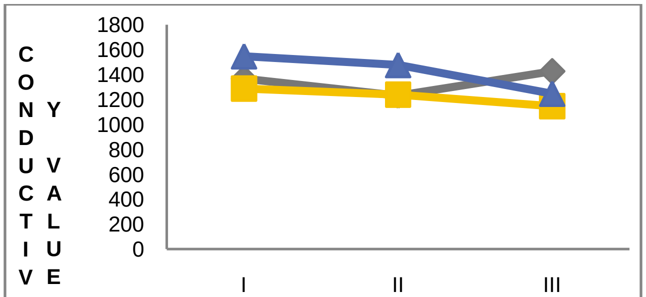
Site wise variation of phvsico-chemical parameters along river Hindon at Muzaffarnagar district, UP



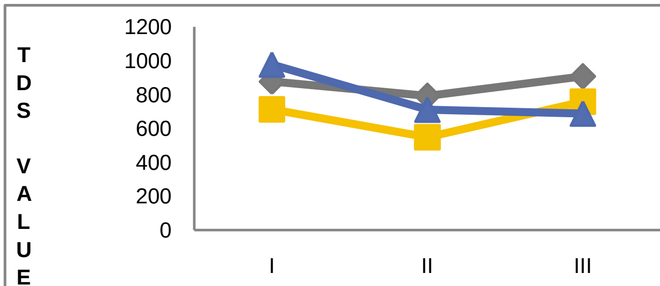
SITES
FIG,2-VARIATION OF PH SAMPLING SITES



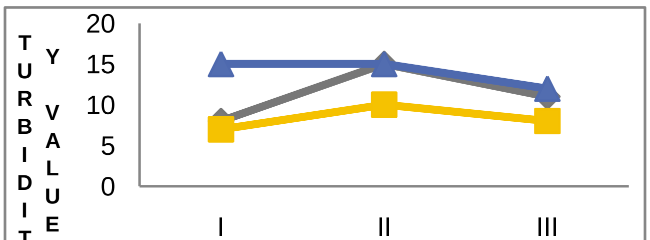
SITES
FIG,6-VARIATION OF TSS WITH SAMLING SITES



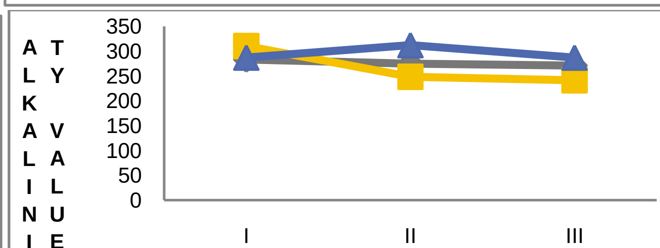
SITES
FIG,3-VARIATION OF CONDUCTIVITY WITH...



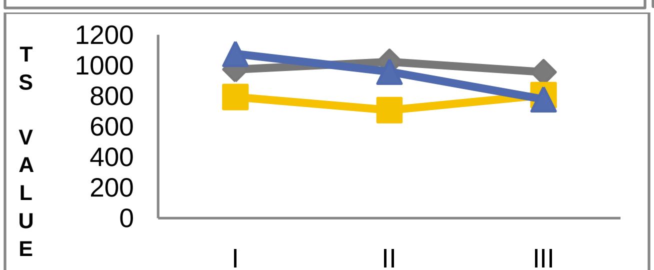
SITES
FIG,7-VARIATION OF TDS WITH SAMPLING SI



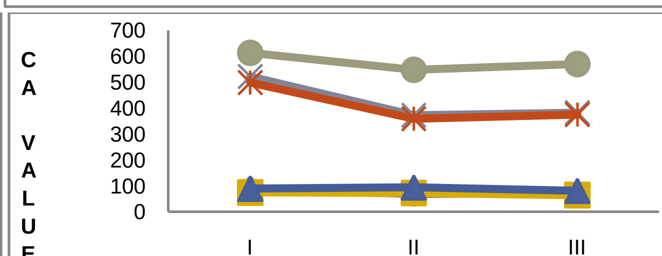
SITES
FIG,4-VARIATION OF TURBIDITY WITH...



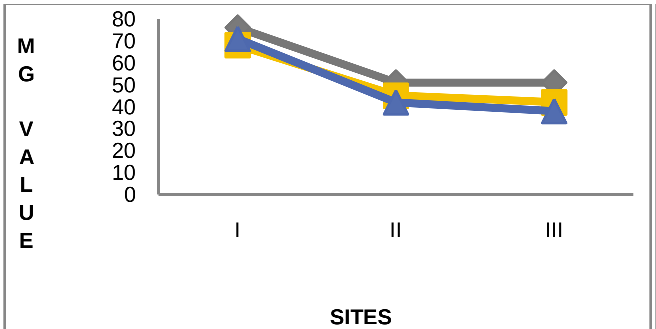
SITES
FIG,8-VARIATION OF ALKALINITY WITH...



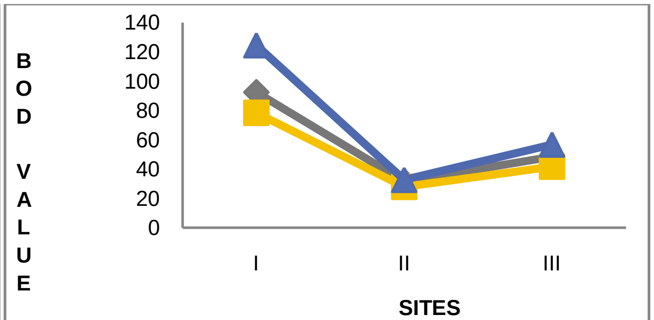
SITES
FIG,5-VARIATION OF TS WITH SAMPLING SITE



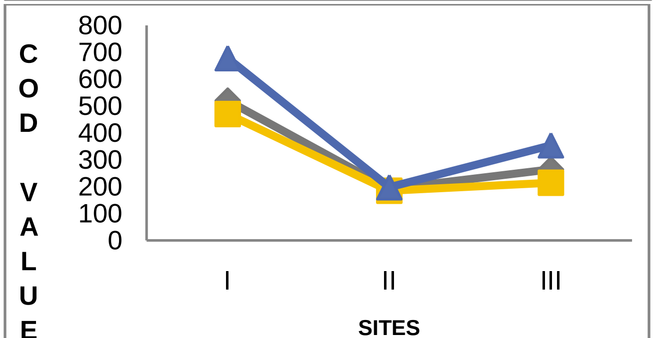
SITES
FIG,9-VARIATION OF CA WITH SAMPLING SITES



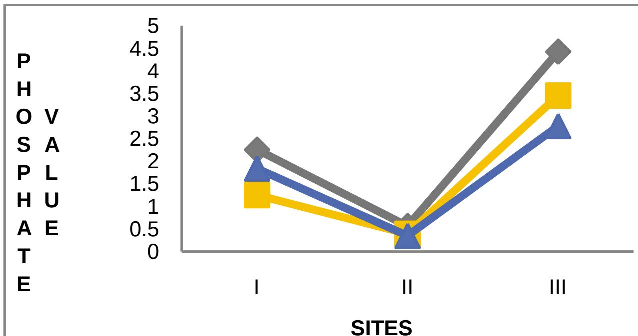
FIG,10-VARIATION OF MG WITH SAMPLING…



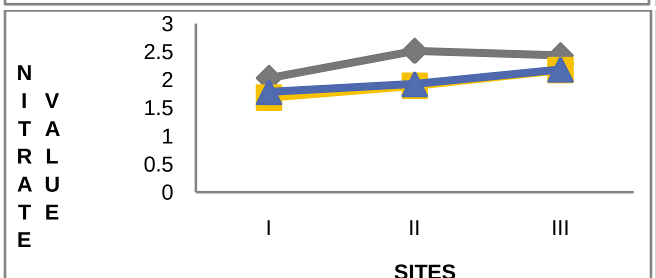
FIG,11-VARIATION OF BOD WITH SAMPLING



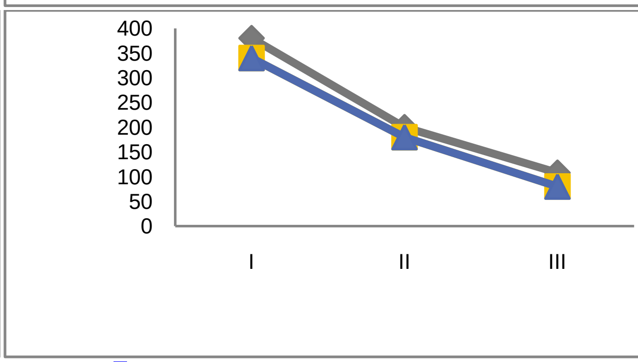
FIG,12-VARIATION OF COD WITH SAMPLING SITES



FIG,13-VARIATION OF PHOSPHATE WITH SAMPLING SITES



FIG,14-VARIATION OF NITRATE WITH…



-monsoon ; Δ -post-monsoon: ◊ -pre-monsoon

Conclusion

Water quality of water samples of three different sampling stations of Hindon river near Muzaffarnagar, District clearly indicates the samples have very high conductivity, turbidity, alkalinity and TSS. The BOD, COD and Phosphate contents exceed from their permissible limit. The pH and alkalinity infer that the water samples are slightly basic in nature. Water samples are also highly bacteriologically contaminated by the presence of total coliform density and fecal coliform. TS, TDS, TH, Ca, Mg and Nitrate contents have been found below the permissible limit. Assessment of Hindon river water using water quality index refers the quality of river water is bad at all site which may be due to overload of effluents. It is concluded that water quality of Hindon river, have been gradually deteriorated which may be due to high industrial pressure and urbanization. In last it is recommended that the point source of pollution should be treated before discharging their wastes into river Hindon, secondly there should be flow augmentation using fresh water through the escapes of Upper Ganga Canal in different stretches of the river at regularly to maintain the quality of the river as it is the life line of the large population living along the river and reviving the river itself.

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