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Limnological studies in relation to pollution of Yamuna River in Agra region

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Abstract
In the present observation, water quality with regard to physical, chemical and biological parameters have been assessed at a specific stretch of the water length of Yamuna river (15m) that has been divided into 4 sites as (a) Kailash ghat, (b) Poiya ghat (non industrial site), (c) Jawahar bridge and (d) near Tajmahal (industrial site). In the present study, rapid increase in number of fecal coliform indicate that level of water pollution increases at an alarming rate. These microbes are responsible for various contaminated diseases. The result of present study shows that except dissolved oxygen all parameters such as temperature, turbidity, conductivity, calcium, chloride, nitrate, sulphate, phosphate, suspended solids, BOD, COD, Coliform and feacal coliform bacteria increases gradually from upstream site A to downstream sites B, C and D sites of Yamuna river. This clearly indicates that the changes in the level of such parameters were due to continuous mixing of pollutants in the Yamuna River.

Keywords: Agra, Faecal coliform, Pollution, Yamuna River.

Introduction
Industrialization, urbanization, population explosion and green revolution have deteriorated the water quality of various water bodies. These environmental changes have had enormous impacts on biodiversity patterns in the past and will remain one of the major drivers of biodiversity patterns in the future (Prakash and Srivastava, 2019) [9]. Biodiversity, agriculture and ecological balance are interrelated (Verma, 2017a, 2018a, 2018b) [18, 21, 22]. As Yamuna river flows from different industrial cities, it becomes polluted due to which B.O.D. in the river often rises to 10 to 20 mg/L against a permissible limit of 3 mg/L. Roughly approximate 650 MLD of municipal waste is also discharged in Yamuna from different cities which are situated on the bank of the Yamuna river in Uttar Pradesh. Many tanneries and silver platting and small pesticide companies are established in Agra. The various wastes in Yamuna water of Agra like tanneries effluents; detergents etc are discharged without any treatment in the river. The population of Agra region nearly 18 $\times 10^5$ and requirement of water is more than 300 MLD but the availability of water is only around 225 MLD. The industrial effluents, sewage and polluted water from other sources like silver platting when discharged into any stream of Yamuna river through Agra, it causes pollution hence authors tried to compare the water quality of Yamuna from upstream site (A) to downstream sites (B, C and D).
Many researchers have studied the limnological condition of various lotic and lentic water bodies including rivers of India *i.e.* Prakash (2001, 2020) [7, 8], Prakash *et al*., (2002, 2015a, 2015b, 2015c, 2020) [10, 11, 12, 13, 8], Singh and Verma (2016) [15], Sugumaran *et al*., (2020) [16], Verma (2016, 2017b, 2017c, 2018c, 2019, 2020) [20, 27, 17, 23, 24, 25], Verma *et al*., (2016a, 2016b) [26, 27], Verma and Prakash (2018, 2020a, 2020b) [28, 29, 30], Bhagde *et al.*, (2020) [2] in relation to plankton, fish fauna and zoobenthos. Some ecologist such as Paliwal *et al.* (2007) [6], Goel *et al.* (2008) [3], Kaushik *et al.* (2009) [4] studied on the physico-chemical and microbial studied on Yammuna river but no attempt has been made so as far to assess the pollution level after 2010 at Yammuna river. Keeping in mind the present investigation was conducted to assess the water quality with regard to physical, chemical and biological parameters at a specific stretch of the water length of Yamuna river (15m) that has been divided into 4 sites as (a) Kailash ghat, (b) Poiya ghat (non industrial site), (c) Jawahar bridge and (d) near Tajmahal (industrial site).

Materials and Methods
Water samples for the present investigation were collected from four sites [A, B, C, D] of the

Yamuna river in Agra after each three months interval from Jan. 2018 to Oct. 2018 and analysed for physico-chemical parameters by following standard methods (APHA, 2005) [1]. For coliform and fecal coliform, samples were collected by filtering two liter of water from each experimental sites, through a planktonic net. Samples were fixed at the spot in 5% formalin, in the laboratory with the help of Sedgewick rafter counting cell and identified.

Results and Discussion

Table 1: shows the experimental data from different sampling stations at different time periods.

Months	Sites/ stations			
	A	B	C	D
Temperature (^{0}C)				
Jan. 2018	16.8	18.0	17.0	17.6
Apr.2018	29	28.5	30.0	29.0
July.2018	31.0	31.5	31.2	32.0
Oct.2018	25	25.9	25.5	25.0
Turbidity (MTU)				
Jan.2018	50.0	57.0	60.0	65.0
Apr.2018	37.0	40.0	50.0	60.0
July.2018	60.0	63.0	64.0	66.0
Oct.2018	57.0	63.0	68.0	78.0
Conductivity (mho)				
Jan.2018	0.510	0.517	0.533	0.549
Apr.2018	0.531	0.537	0.549	0.566
July.2018	0.418	0.449	0.432	0.501
Oct.2018	0.436	0.440	0.444	0.481
Calcium (mg/l)				
Jan.2018	290.0	296.0	314.0	396.0
Apr.2018	288.0	292.0	300.0	404.0
July.2018	280.0	284.0	312.0	430.0
Oct.2018	238.0	244.0	265.0	374.0
Chloride (mg/l)				
Jan.2018	260.12	266.90	310.84	618.34
Apr.2018	241.73	252.10	381.50	647.32
July.2018	276.08	281.50	370.00	589.85
Oct.2018	216.8	220.42	284.60	455.40
Nitrate Nitrogen (mg/l)				
Jan.2018	284.60	455.40	284.60	455.40
Apr.2018	1.82	1.84	1.85	1.81
July.2018	4.82	4.83	4.84	4.83
Oct.2018	4.84	4.83	4.84	4.83
Sulphate (mg/l)				
Jan.2018	19.00	25.02	21.12	26.50
Apr.2018	25.02	21.17	23.46	26.59
July.2018	17.41	21.00	21.14	123.72
Oct.2018	17.44	24.42	21.00	33.08
Phoshate (mg/l)				
Jan.2018	0.91	0.85	0.61	0.43
Apr.2018	0.57	0.54	0.03	1.86
July.2018	0.64	0.69	0.72	0.78
Oct.2018	0.37	0.45	0.63	0.73
Suspended Solids (mg/l)				
Jan.2018	109.0	121.0	158.0	190.0
Apr.2018	78.0	102.0	149.0	234.0
July.2018	157.0	173.0	219.0	278.0
Oct.2018	89.0	97.0	132.0	164.0
Dissolved Oxygen(mg/l)				
Jan.2018	8.3	8.1	7.5	6.0
Apr.2018	7.9	7.6	6.9	3.5
July.2018	7.0	7.1	7.1	6.7
Oct.2018	7.2	7.3	7.0	5.8
B.O.D. mg/L				
Jan.2018	9.1	10.5	14.0	25.0
Apr.2018	10.1	12.5	19.0	82.0
July.2018	12.5	14.0	23.0	130.0
Oct.2018	13.6	15.2	24.1	145.0
C.O.D. mg/L				
Jan.2018	28.0	35.0	65.0	180.0

Apr.2018	31.0	39.0	72.0	220.0
July.2018	37.0	40.0	35.0	260.0
Oct.2018	25.0	36.0	42.0	90.0
Coliform (100ml)				
Jan.2018	14933.67	21696.89	40637.68	82892.00
Apr.2018	7478.00	166252.0	458343.00	580260.00
July.2018	4263.00	3743.67	8766.00	13987.00
Oct.2018	3364.96	9266.92	62986.9	243000.00
Feacal Coliform (100ml)				
Jan.2018	16766.00	48233.33	114000.00	198666.00
Apr.2018	43303.00	127333.67	216790.87	548666.00
July.2018	2483.34	68760.36	108267.33	147689.33
Oct.2018	2566.68	6589.67	99688.78	258687.00

It is clear that except dissolved oxygen all parameters such as temperature, turbidity, conductivity, calcium, chloride, nitrate, sulphate, phosphate, suspended solids, BOD, COD, Coliform and feacal coliform bacteria increases gradually from upstream site A to downstream sites B, C and D sites of Yamuna river. The result clearly indicates that these changes in the level of such parameters were due to urbanization and small scale iron foundries, leather and silver plating industries are responsible for pollution in the Yamuna River, which is going to increase regularly due to direct throwing of wastes in the Yamuna.

As the level of pollution increases, the number of fecal coliform per 100 ml will also increase rapidly. This will be an alarming situation as various contaminant diseases may be caused due to these microbes. Authors also found that polluted materials are continuously mixing in the Yamuna river by various small and large industries situated on the bank of Yamuna river in Agra. All these parameters are alarming for people of Agra because pollution level has increased from upstream to downstream site. The fecal coliform and coliform are increasing rapidly which are responsible for various contaminants diseases for human beings as well as cattle, related with this water.

It is clear that industrialization urbanization, population explosions are causes to deteriorate the various sources of water. The industrial effluent, sewage and polluted water from other sources are continuously discharging into the Yamuna River.

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