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Impact Assessment of Gomti River Water Quality after Immersion of Idols During Durga Utsav

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Abstract

In present study, an attempt has been made to assess the deterioration of water quality of river Gomti after the immersion of idols in Lucknow city. Water samples were collected (pre, during and post-idol immersion) from 4 selected locations (1 upstream and 3 downstream) during the festival month. All samples were analyzed for physico-chemical and metallic characteristics. The mean concentrations of TSS, TDS, alkalinity, hardness, DO and BOD5 were 29 ± 7, 183 ± 9, 159 ± 20, 130 ± 5, 6.40 ± 0.18, 20.50 ± 2.38 mg/L and EC was 0.35 ± 0.02 µS/cm (before idol immersion); 61 ± 13, 260 ± 47, 202 ± 11, 162 ± 14, 5.90 ± 0.41, 29 ± 7 mg/L and EC was 0.41 ± 0.02 µS/cm (after 6 hr of idol immersion) and 25 ± 4, 205 ± 17, 206 ± 14, 137 ± 8, 6.00 ± 0.26, 22.0 ± 3.6 mg/L and EC was 0.40 ± 0.02 µS/cm (post-idol immersion) respectively. The mean concentration of metals like Pb, Cr, Cd and Zn were 0.007 ± 0.013, 0.021 ± 0.023, 0.001 ± 0.000 and 0.021 ± 0.013 mg/L (before idol immersion), 0.070 ± 0.013, 0.127 ± 0.035, 0.013 ± 0.014 and 0.038 ± 0.028 mg/L (after 6 hr of idol immersion) and 0.008 ± 0.004, 0.267 ± 0.304, 0.013 ± 0.014 and 0.031 ± 0.009 mg/L (post-idol immersion) respectively. All physico-chemical and metallic parameters of water samples drawn after idol immersion was found increased to measurable levels as compared to the samples collected before idol immersion. The analysis results confirmed the presumed hypothesis that water quality of river Gomti is adversely affected due to the immersion of idols during festival season.

Keywords: Gomti river; Gurga utsav; Idol immersion; Physico-chemical; Metallic parameters

Introduction

The Gomti river is one of the major tributaries of the Ganga instigates from a reservoir in the marshy and heavily woody area near Madho-Tanda (Miankot) with an elevation of 200 m. It is originated about 50 km south of the Himalaya foot-hills and about 3 km east of Pilibhit in Uttar Pradesh. Assessment of river water quality used for drinking and domestic purpose should be an important criterion from public health point of view especially when unwanted things that can damage the quality of water are thrown into the water bodies [1]. The Quality of water is of vital concerns for human beings, since it is directly linked to human health and other living creatures. Besides, urbanization, the material used in religious rituals like flowers, incense sticks, food, sweets, clothes etc is dispersed in nullahs and Gomti results in pollution and deterioration of river water quality which supply as portable water for urban population [2]. Durga Utsav is one such famous Hindu festival celebrated during the month of October. Traditionally, hundreds of idols of Goddess Durga and Lord Ganesha are immersed in the river water on this occasion every year, containing biodegradable and non-biodegradable materials. Festivals are an integral part of ritual and diverse cultural heritage of India. Durga Utsav is one such famous Hindu festival celebrated during the month of October. Every year on this occasion, thousands of large and small idols of Goddess Durga and Lord Ganesha are immersed in the river water. These idols are containing innumerable biodegradable and non-biodegradable compounds [1,3]. These idols are made of many materials viz. plaster of paris, papers, clay, colors, jutes, clothes, wooden frame, thermocol etc [1,4]. An analysis of water samples in Assam at Kacharighat on the post-immersion night of Durgapuja established the presence of heavy metals like lead, chromium, nickel, cadmium and zinc to a significant extent [5]. In Maharashtra Pollution Board formulated guidelines and recommendations for idol immersion [6]. Tamil Nadu Pollution Control Board banned immersion of Vinayaka idols in water bodies on August 5 2009 [7-9]. A number of persistent colors and toxic chemicals leach from these idols disperse in the river water [10,11]. These toxic non-biodegradable chemicals enter into the water bodies' then human health through food chain. With the advancement of scientific knowledge, it becomes imperative after the immersion of idols to assess the magnitude of deterioration of river water quality through water quality index and further to protect the river water quality. In this study, an attempt has been made to assess the deterioration of water quality of the river Gomti after the idol emersion. So that possible measures can be executed to protect river water quality.

Materials and Methods

Sampling locations and frequency

In the present investigation, twelve river water samples were collected (pre, during and post-idol immersion period) from 4 selected locations 1 upstream (Daliganj Bridge) and 3 downstream (Idol immersion site, Khatu Ashram and Near Barrage) during the festival month (October 2013). All samples were analyzed for physico-chemical and metallic characteristics. First set of water samples were collected a week before the idol immersion activities. During idol immersion, samples were collected after 6 hr of idol immersion activities and Post-idol immersion samples were collected 3 days after the completion of

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immersion activities. Water sampling was carried out in acid washed polyethylene bottles of 2 L capacity. After sample collection, HNO_3 was added to it for avoiding microbial degradation.

Procedures of analysis

All physico-chemical parameters were analyzed within 6 hrs whereas temperature, pH, DO, were checked at the spot during sampling. The analysis procedure is based on APHA in 2006 [7]. DO samples were fixed at the site itself and were analysed in the laboratory by Winkler's method with azide modification. COD was determined using potassium dichromate open reflux method. The hydrogen ion concentration (pH) of water samples were measured using an electrode (Eutech- pH 700). Determination of chlorides was done by argentometric titration while nitrate was assessed by UV spectrophotometric screening method. TDS and TSS was measured by gravimetric method. Total alkalinity and total hardness were computed by titrimetric method using sulphuric acid and EDTA solutions, respectively. Sulfate was measured following turbidimetric method. Phosphate was analyzed by stannous chloride method. Fluoride was determined by the potentiometric method, with an electrode specific to fluoride ion. For metal analysis, water samples were digested with acid mixture on hot plate and their concentrations were measured by AAS [12-14].

Results and Discussion

The analyses results of physico-chemical parameters of Gomti River summarized in Figures 1 to 3 and Table 1. The average pH has increased significantly due to the immersion of idols i.e.; 8.00 ± 0.09, in pre-idol immersion it was 7.80 ± 0.08 and it again decreased down to 7.74 ± 0.09 after 3 days. Electrical conductivity was found 0.35 ± 0.02 µS/cm (pre-idol immersion), 0.41 ± 0.02 µS/cm (during-idol immersion) and 0.40 ± 0.02 µS/cm (post-idol immersion) respectively. DO is an important parameter for indicator the physical, chemical and biological activities of water body. It was 6.40 ± 0.18 mg/L during pre-immersion but deceased down during immersion period i.e., 5.90 ± 0.41 mg/L because of increasing pollution. The higher values of BOD5 have direct correlation with bio-degradable materials. DO of surface water is inversely proportional to BOD5. The maximum BOD5 value was observed during immersion period was 29.0 ± 7.0 mg/L due to increase amount of decomposition of organic matter into the river water. The maximum COD value 50.50 ± 6.40 mg/L was recorded during immersion period and the lowest value was 34.80 ± 5.73 mg/L during pre-immersion phase. The values of hardness in river water were found to be 130 ± 5, 162 ± 14 and 137 ± 8 mg/L in pre, during and post immersion periods respectively. The values of total hardness in this river were below the tolerance limit prescribed by BIS [8] (Figures 1-3).

However, the presence of high levels of TDS in water may be objectionable, results in salinity of water. In present study, TDS in all the periods in different locations were within the permissible limit. The mean concentration of TDS was 260 ± 47 mg/L (during-idol immersion) and 183 ± 9 and 205 ± 17 mg/L (pre and post-idol immersion). Dissolve and suspended solids not only reduced the penetration of sunlight in river water but also decrease the rate photosynthesis and overall productivity which in turn disturbs the whole river ecosystem. Sulphate, nitrate and phosphate were found within their permissible limits of drinking water given by and IS: 10500 (2012) [8,15]. The percentage (%) increase of others parameters are given below: pH

Pre-idol Immersion																	
Sampling Sites	**pH**	**Temp**	**EC**	**TDS**	**TSS**	**Hardness**	**Alkalinity**	**DO**	**BOD_5**	**COD**	**CO_2***	**Free Cl^-**	**Chloride**	**Sulfate**	**Nitrate**	**Inorg PO_4^{2-}**	**Fluoride**
Daliganj Bridge	7.40	25	0.32	170	18	135	188	6.6	19	28	20	2.09	8	18.6	0.48	0.25	0.22
Idol Immersion	7.48	25	0.35	184	30	132	158	6.5	24	42	18	2.67	24	17.4	0.54	0.25	0.21
Khatu Ashram	7.50	26	0.38	190	32	124	149	6.2	20	35	25	2.15	16	19.5	0.79	0.29	0.21
Near Barrage	7.60	26	0.36	188	34	128	142	6.3	19	34	32	1.81	13	21.4	0.78	0.28	0.22
Avg	7.50	26	0.35	183	29	130	159	6.4	20.5	34.8	24	2.18	15	19.23	0.65	0.27	0.22
Min	7.40	25	0.32	170	18	124	142	6.2	19.0	28.0	18	1.81	8	17.40	0.48	0.25	0.21
Max	7.60	26	0.38	190	34	135	188	6.6	24.0	42.0	32	2.67	24	21.40	0.79	0.29	0.22
SD	0.08	1	0.02	9	7	5	20	0.18	2.38	5.73	6	0.36	7	1.69	0.16	0.02	0.01
During idol Immersion																	
Daliganj Bridge	8.11	28	0.39	210	43	152	186	6.3	19	42	34.0	2.5	14	23.8	0.84	0.45	0.35
Idol Immersion	8.04	28	0.42	244	63	148	204	6.2	36	49	26.4	3.7	32	23.5	1.16	0.54	0.37
Khatu Ashram	7.93	28	0.42	322	74	176	210	5.4	31	56	35.2	2.3	28	24.2	1.68	0.59	0.36
Near Barrage	7.91	29	0.42	262	63	172	208	5.8	28	55	44.0	2.8	24	24.1	1.61	0.52	0.35
Avg	8.00	28	0.41	260	61	162	202	5.9	29.0	50.5	34.9	2.8	25	23.9	1.32	0.52	0.36
Min	7.91	28	0.39	210	43	148	186	5.4	19.0	42.0	26.4	2.3	14	23.5	0.84	0.45	0.35
Max	8.11	29	0.42	322	74	176	210	6.3	36.0	55.8	44.0	3.7	32	24.2	1.68	0.59	0.37
SD	0.09	0	0.02	47	13	14	11	0.41	7.0	6.40	7.2	0.61	8	0.32	0.39	0.06	0.01
Post-idol Immersion																	
Daliganj Bridge	7.80	27	0.38	188	19	132	186	6.3	17	39	32	2.42	18	21.7	0.82	0.31	0.29
Idol Immersion	7.60	28	0.39	193	26	137	208	6.2	25	49	29	2.98	25	21.5	0.77	0.36	0.31
Khatu Ashram	7.74	27	0.42	214	29	129	218	5.8	24	48	34	2.66	25	22.2	0.95	0.33	0.29
Near Barrage	7.80	28	0.42	223	24	148	212	5.8	22	47	37	2.11	19	22.3	1.12	0.31	0.28
Avg	7.74	28	0.40	205	25	137	206	6.0	22.0	46	33	2.54	22	21.90	0.92	0.33	0.29
Min	7.60	27	0.38	188	19	129	186	5.8	17.0	39	29	2.11	18	21.46	0.77	0.31	0.28
Max	7.80	28	0.42	223	29	148	218	6.3	25.0	49	37	2.98	25	22.25	1.12	0.36	0.31
SD	0.09	1	0.02	17	4	8	14	0.26	3.6	5	3	0.37	4	0.38	0.16	0.02	0.01
*Free CO_2																	

Table 1: Changes in concentrations of physico-chemical parameters of Gomti river (pre-idol immersion during idol immersion and post-idol immersion).

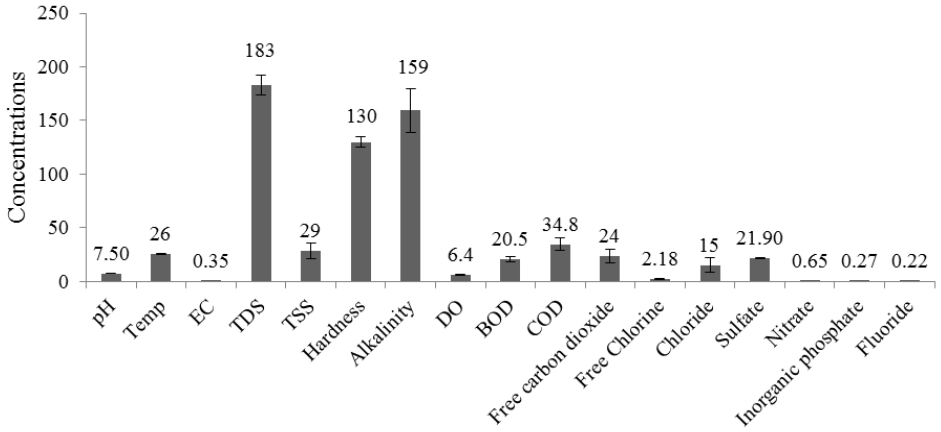

Figure 1: Physico-chemical characteristics of Gomti river water quality during pre-idol immersion.

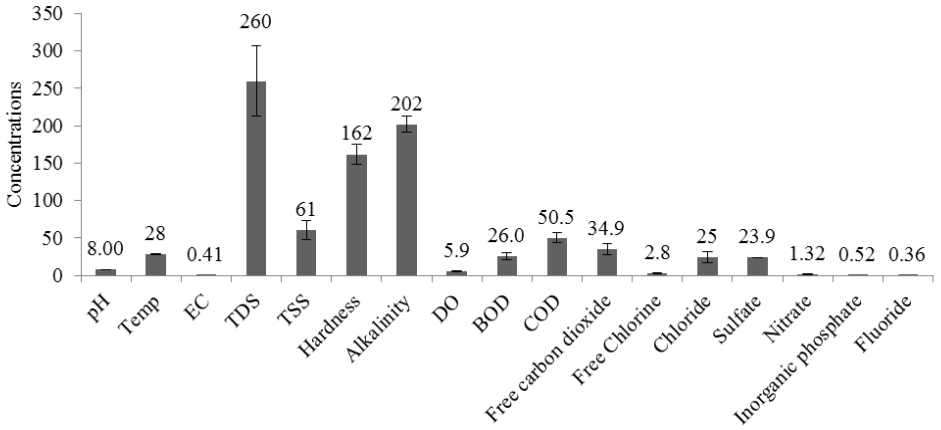

Figure 2: Physico-chemical characteristics of Gomti river water quality during idol immersion.

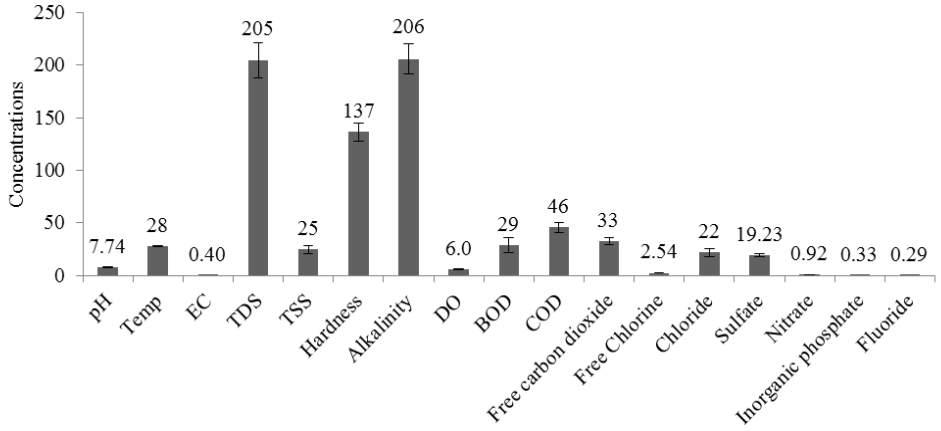

Figure 3: Physico-chemical characteristics of Gomti river water quality during post-idol immersion.

(3.20), temperature (6.78), electrical conductivity (14.80), TDS (11.75), hardness (5.20), alkalinity (29.36), BOD5 (39.02), COD (31.47), free carbon dioxide (38.21), free chlorine (16.63), chloride (42.70), nitrate (41.51), inorganic phosphate (22.93) and fluoride (36.05) respectively.

The range of metals concentrations of the Pb, Cr, Cd and Zn were found 0.070 ± 0.013, 0.127 ± 0.035, 0.013 ± 0.014 and 0.038 ± 0.028 during-idol immersion period which were markedly higher as compared to the pre and post-idol immersion data (Table 2).

The statistical correlation is board class of statistical relationship between two or more variables. The correlation coefficients for

	Pre-idol Immersion												
Sampling Sites	**Ni**	**Cr**	**Mg**	**Ca**	**Zn**	**Cu**	**Fe**	**Na**	**Mn**	**Cd**	**K**	**Pb**	**Co**
Daliganj Bridge	0.001	0.001	4.21	30.56	0.001	0.001	0.60	11.31	0.029	0.001	0.21	0.001	0.001
Idol Immersion	0.001	0.036	5.48	38.96	0.027	0.001	0.63	12.20	0.003	0.001	0.19	0.001	0.001
Khatu Ashram	0.001	0.044	5.66	36.36	0.029	0.001	0.64	13.42	0.026	0.001	0.17	0.026	0.001
Near Barrage	0.001	0.001	4.96	29.36	0.026	0.001	0.55	12.69	0.031	0.001	0.11	0.001	0.001
Avg	0.001	0.021	5.078	33.810	0.021	0.001	0.605	12.405	0.022	0.001	0.170	0.007	0.001
Min	0.001	0.001	4.210	29.360	0.001	0.001	0.550	11.310	0.003	0.001	0.110	0.001	0.001
Max	0.001	0.044	5.660	38.960	0.029	0.001	0.640	13.420	0.031	0.001	0.210	0.026	0.001
SD	0.000	0.023	0.650	4.597	0.013	0.000	0.040	0.886	0.013	0.000	0.043	0.013	0.000
	During-idol Immersion												
Daliganj Bridge	0.001	0.084	14.478	60.056	0.001	0.001	2.304	14.52	0.055	0.001	0.361	0.077	0.001
Idol Immersion	0.029	0.164	22.110	82.976	0.062	0.001	3.092	18.84	0.065	0.024	0.134	0.084	0.001
Khatu Ashram	0.001	0.144	15.696	83.336	0.058	0.001	0.458	17.04	0.001	0.025	0.224	0.053	0.001
Near Barrage	0.001	0.116	13.716	55.536	0.034	0.001	1.054	17.35	0.053	0.001	0.200	0.067	0.001
Avg	0.008	0.127	16.500	70.476	0.038	0.001	1.727	16.935	0.043	0.013	0.230	0.070	0.001
Min	0.001	0.084	13.716	55.536	0.001	0.001	0.458	14.518	0.001	0.001	0.134	0.053	0.001
Max	0.029	0.164	22.110	83.336	0.062	0.001	3.092	18.840	0.065	0.025	0.361	0.084	0.001
SD	0.014	0.035	3.828	14.758	0.028	0.000	1.192	1.794	0.029	0.014	0.095	0.013	0.000
	Post-idol Immersion												
Daliganj Bridge	0.001	0.001	7.41	41.3	0.001	0.001	0.76	11.98	0.026	0.001	0.29	0.001	0.001
Idol Immersion	0.029	0.46	8.8	47.6	0.043	0.001	0.89	13.34	0.034	0.001	0.33	0.001	0.001
Khatu Ashram	0.022	0.58	8.06	46.6	0.029	0.001	0.91	15.78	0.001	0.029	0.27	0.029	0.001
Near Barrage	0.024	0.001	7.86	45.54	0.025	0.001	0.83	14.66	0.001	0.001	0.08	0.001	0.001
Avg	0.019	0.261	8.033	45.259	0.025	0.001	0.848	13.940	0.016	0.008	0.268	0.008	0.001
Min	0.001	0.001	7.410	41.300	0.001	0.001	0.760	11.980	0.001	0.001	0.180	0.001	0.001
Max	0.029	0.580	8.800	47.600	0.043	0.001	0.910	15.780	0.034	0.029	0.330	0.029	0.001
SD	0.012	0.304	4.127	2.771	0.017	0.000	0.068	1.644	0.017	0.014	0.063	0.014	0.000

Table 2: Changes in metal concentrations (mg/L) of Gomti river (pre-idol immersion during idol immersion and post-idol immersion).

Metals	**Ni**	**Cr**	**Mg**	**Ca**	**Zn**	**Cu**	**Fe**	**Na**	**Mn**	**Cd**	**K**	**Pb**	**Co**
Ni	1	-	-	-	-	-	-	-	-	-	-	-	-
Cr	0.709**	1	-	-	-	-	-	-	-	-	-	-	-
Mg	0.977*	0.780**	1	-	-	-	-	-	-	-	-	--	-
Ca	0.565	0.840**	0.723**	1	-	-	-	-	-	-	-	-	-
Zn	0.554	0.979*	0.637	0.809**	1	-	-	-	-	-	-	-	-
Cu	0.996	0.709	0.977	0.565	0.554	1	-	-	-	-	-	-	-
Fe	0.764**	0.093	0.686	0.091	-0.111	0.764	1	-	-	-	-	-	-
Na	0.708**	0.917*	0.697	0.556	0.898**	0.708	0.125	1	-	-	-	-	-
Mn	0.500	-0.174	0.321	-0.419	-0.329	0.501	0.815**	0.081	1	-	-	-	-
Cd	0.553	0.889**	0.704**	0.992*	0.874**	0.553	0.019	0.633	-0.445	1	-	-	-
K	-0.667	-0.900*	-0.651	-0.519	-0.891**	0.551	-0.079	-0.998*	-0.068	-0.603	1	-	-
Pb	0.667	-0.049	0.545	-0.131	-0.243	-0.667	0.972*	0.069	0.926*	-0.192	-0.034	1	-
Co	0.996	0.709	0.977	0.565	0.554	0.977	0.764	0.708	0.501	0.551	-0.667	0.666	1

*Significant at 0.01 level
**Significant at 0.05 level

Table 3: Correlation matrix of metal concentrations of Gomti river (during idol immersion).

different metals are given in Table 3. The correlation is considered well if $r > 0.6$ and marginal of $0.47 < r < 0.6$. Ni, Cr, Mg, Ca, Cu, Fe and Mn correlated strongly with Mg, Cu, Ca, Zn, Na, Cu, Co, Cd, Co and Pb ($r = 0.977, 0.996, 0.996, 0.979, 0.917, 0.977, 0.977, 0.992, 0.977, 0.972$ and 0.926 respectively). The Ni with K; Cr with Mn, K and Pb; Mg with K; Ca with Mn, K and Pb; Zn with Fe, Mn, K and Pb; Fe with K; Na with K; Mn with Cd and K; Cd with K and Pb; K with Pb showed a negative correlation. A significance correlation was seen between Ni with Mg, Cu, Co; Cr with Zn and Na; Mg with Cu, Ca; Ca with Cd; Cu with Co; Fe with Pb and Mn with Pb. A positive correlation was seen between Mn to Cd, K, Pd and Co. A significance correlation was seen between Cr to Ca, Cd and Ca to Zn, Cd.

Accumulation of cadmium in human body produces the toxicity of liver and kidney. Lead is a cumulative general poison, with infants, children up to 6 years of age, the fetus and pregnant women being the most susceptible to adverse health effects. Its effects on the central nervous system can be particularly serious [16]. Acute exposure of Cr results in gastrointestinal disorders, hemorrhagic diathesis and convulsions and cancerous in chronic exposure. Iron was also found

excess in during-idol immersion period (1.727 ± 1.192 mg/L). Excess amount of body iron causes gastrointestinal problem. The heavy metals are known to be persistent in the aquatic environment and gradually magnify through the bioaccumulation and biomagnifications in the subsequent tropic level, when they migrate from one tropic level to higher one. All the rivers end up with the merging of sea and thereby contaminating the sea food also.

Conclusion

Our study results showed that most of the water quality parameters monitored during and post idol immersion were significantly increased. This indicates that the water quality of river Gomti is adversely affected due to the immersion of idols during festival seasons. The various bodies including educational bodies, Municipal Corporation, Pollution Control Board, Civil society and every citizen of Lucknow may participate to increase the public awareness regarding the pollution. Authority can suggest some alternative measures and implement central and state level legislations without hurting the religious sentiments of mass people. Every year, there should be an occasion of Gomti water cleaning programs and disseminate information to protect and pollution.

Competing Interests

There was no financial support provided by any agency. This study was based on our Institute fund. Both of the authors have read the manuscript thoroughly. All financial and non-financial competing interests must be declared in this section. Authors have no competing interest for publication.

Authors' Contributions

Both of the authors have equally contributed for preparation of manuscript. The experimental data generated by first author and finalization was done by second authors.

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References

1. Vyas A, Bajpai A, Verma N (2008) Water quality improvement after shifting of idol immersion site: A case study of Upper Lake, Bhopal, India. Environ Monit Assess 145: 437-443.
2. Singh KP, Mohan D, Singh VK, Malik A (2005) Studies on distribution and fractionation of heavy metals in Gomti river sediments-a tributary of the Ganges, India. J Hydro 312: 14-27.
3. Sheetal P, Musaddiq M, Budhlani GN, Khan J (2014) Ganesh idol immersion and its impact on water quality of Tapti river, Burhanpur, MP, India 34-40.
4. Smitha AD, Shivashankar P (2013) Physico chemical analysis of the freshwater at river Kapila, Nanjangudu Industrial Area, Mysore, India. Int Res J Environ Sci 2: 59-65.
5. Nisha U, Jain RK, Saxena AK, Shrivastava PK, Rajshree S (2013) Effect of idol immersion on water quality of lakes of Bhopal, MP, India. J chem biol phys sci 4: 841-848.
6. Shukla NK, Markandeya S, Shukla VK (2015) Arsenic and physico-chemical calamity in the ground water samples of Ballia district, Uttar Pradesh, India, Iranica Journal of Energy and Environment 6: 328-333.
7. APHA (2006) American Public Health Association (22ndedn) DC, USA.
8. IS:10500 (2012) Drinking water- specifications (second revision).
9. Valipour M (2013) Use of surface water supply index to assessing of water resources management in Colorado and Oregon, USA.
10. Valipour M (2014) Handbook of drainage engineering problems. Publisher: OMICS Group International.
11. Valipour M (2015) Handbook of environmental engineering problems. Publisher: OMICS Group International.
12. Tiwari M, Shukla NK, Kumar V, Ojha AK, Ahmad I (2015) Seasonal variation of groundwater quality of Amethi District. International Journal of Advanced Multidisciplinary Research (IJAMR) 6: 1-9.
13. Tiwari M, Shukla NK, Kumar V, Sharma GD, Gupta MK, et al. (2015) Assessment of ground water quality of Hamirpur District, Uttar Pradesh, India. Int J Curr Microbiol App Sci 4: 597-603.
14. Kumar A, Kumar V, Dhiman N, Ojha A, Bisen P, et al. (2016) Consequences of environmental characteristic from livestock and domestic wastes in wetland disposal on ground water quality in Lucknow (India). Int J Environ Res Public Health 3: 112-119.
15. Valipour M (2013) Evolution of irrigation-equipped areas as share of cultivated areas. Irrigat Drainage Sys Eng 2:e114.
16. Valipour M (2012) A comparison between horizontal and vertical drainage systems (includes pipe drainage, open ditch drainage, and pumped wells) in anisotropic soils. Journal of Mechanical and Civil Engineering 4: 7-12