REVIEW ARTICLE

Assessment of heavy metals and their effects on quality of water of rivers of Uttar Pradesh, India: A review

Gulrez Nizami, Shifa Rehman

Nizami G, Rehman S. Assessment of heavy metals and their effects on quality of water of rivers of Uttar Pradesh, India: A review. J Environ Chem Toxicol. 2018;2(2):65–71.

Uttar Pradesh the largest state of India is blessed with most holy and important rivers in its region but due to increased urbanization and industrialization these rivers are under intimidation of high-water pollution. The aim of the manuscript is to critically review the extent of heavy metal pollution in specific sites of five prominent rivers of state of Uttar Pradesh namely Ganga at Allahabad, Ganga at Varanasi, Gomti at Lucknow, Yamuna at Allahabad and Ramganga at Moradabad. The attempts have been made to determine the extent of water pollution in these rivers comparatively. The aim of the manuscript is to put forth a comparative overview of the state–of–the–art knowledge on the heavy metal pollution in these rivers. As per the study undertaken by several researchers, the levels of heavy metal viz. Fe, Mn, Zn, Pb and Cd at different sites in Ganga River, Varanasi reported to be highest. Similarly, the status of these metals, Mn Cr Cu, Zn, Pb and Fe concentrations in the Ganga River water various sites of Allahabad region found exceeding. Another very important river of UP, Yamuna at Allahabad is selected due to its high level of pollution. Heavy metals (Pb, Cu and As) concentrations were found high in water from River. The heavy metals concentration in water found that Pb and Cu were higher than the permissible limits of WHO, which is sign of hazard to the environmental health. In Gomti River at Lucknow the high traces of all the metals were obtained in water and deposit in rainy season compared to summer and winter due to the overflow from open polluted sites, agricultural fields and industries. The concentration of Zn was found more than the permissible limits. The river Ramganga an important tributary to the Ganga river is also facing excessive threat of pollution. The concentration of heavy metals showed increasing trends in summer compared to monsoon and winter period. The heavy metals contamination in all the five rivers was found to be influenced by mainly municipal and industrial waste of cities.

Key Words: *Environmental health; Heavy metals; WHO; Industrial waste*

INTRODUCTION

Water is vital to maintain the existence on earth. The rapid industrialization and metropolitan expansion consequences in addition of range of contaminants into water bodies [1] as well as due to the erosion and weathering heavy metals containing geographical derivation reached the stream bodies [2]. Water possess characteristic feature of dissolving a vast range of chemicals and transporting them in suspension . Due to which water considerably turn into impure and polluted form. Man created actions like mining, removal of treated and untreated throw away discharge consisting of contaminated metals and their complexes [3] as of various industries like nuclear power stations, steel industries, battery plants and tannery sites etc. Indiscriminate use of pesticides containing heavy metals in agricultural fields is accountable for heavy metal pollution in ground and surface water. Heavy metal pollution exerts adverse effects on environment and living organisms [4,5]. Inadequate metropolitan sanitary transportation, lack of well–organized implementation of desirable pollution control measures has complicated the condition [6]. The heavy metals and inorganic pollutants of stream water have gain the attention of scientists of all over world due to their non–degradable nature which creates a lethal biological effect on living organisms when added frequently through tropic level [7]. Ram Ganga River is also found highly contaminated like other mentioned rivers due to the rapid anthropogenic expansion around it.

And consequently, responsible for discharge of huge runoff and release of crude sewage in Uttarakhand [8]. Since we all know that many of the heavy metals as Cu, Ni, Zn, Fe and Mn are considered to be micronutrient for living functions in vegetation and microbes whereas a lot of metals like Cd, Pb, Cr do not hold recognized physiological functions, because beyond a definite level these metals are found injurious [9], maximum limit is almost negligible for several elements like Pb (0.10 mg/l), Cd (0.01 mg/l) and Cu (0.050 mg/l). The dangerous illness like tumor, congestion of pharynx and nasal passage membrane, staleness of the cranium, gastrointestinal, decay of muscles, degeneration of reproductive system, disturbance of neurological and hereditary system resulted by a number of these heavy metals [10]. The higher ranks of heavy metals can be found in and around discussed study areas due to liberation and scattering of mine litters into adjoining cultivated lands, foodstuff harvests and watercourse structures. Ultimately, they might stance a latent well–being threat to populaces in the locality of excavating zones. Various investigations have been showed on heavy metal pollution in soils, floras, waters and residues from metalliferous mines all over the biosphere [11–14]. Several researchers have conversed the passage of heavy metal elements subjective by their chemical composition and the potential ecological complications [15,16] The present paper is the review of status of five major rivers of Uttar Pradesh on account of their concentration of heavy metals and their effects on quality of water for drinking and irrigation purpose.

LITERATURE REVIEW

Present paper is a review of effect of heavy metals on five most important rivers of Uttar Pradesh. The aim of the paper is to review the water quality of the most important rivers of entire UP for oral consumption and agricultural function. The study area chosen for this work is the Ganga River in Allahabad and Varanasi, which is considered largest river of India, suffering from high threat of pollution and causing considerable intimidation to human health and environment [17]. Ganga is included among the five most polluted rivers in the world [18]. According to Hindu mythology it is a belief that cremation on Ganga bank and to flow downward the Ganga will provide salvation. It was estimated that about forty thousand dead bodies are burnt per year in Varanasi merely and many of them are hal–cremated [19]. Sangam, the place where Ganga and the Yamuna rivers meet in Allahabad is the third study area which is included in four extremely contaminated stretches in the longest Indian River because the water report released by central pollution control board (CPCB) has declared 39 stations in Allahabad as in adequate in their water quality. The fourth study area is River Gomti at Lucknow UP due to the rapid development and industrialization on its bank. The year ending March 2016, scheduled in currently Vidhan Sabha reported as Water quality of the Ganga at Varanasi is better but the feature of the gomti water deteriorated. River Ramganga at Moradabad is the fifth site for this review study due to their advance degree of contamination by the waste discharge by brass industries. Some studies also showed that Ramganga is most polluted at Moradabad, research conducted by UP council for Agriculture Research (UPCAR).

Faculty of Science, Department of Chemistry, Mohammad Ali Jauhar University, Rampur, Uttar Pradesh, India

Correspondence: Gulrez Nizami, Faculty of Science, Department of Chemistry, Mohammad Ali Jauhar University, Rampur, Uttar Pradesh, India. Telephone 075993 61707, e-mail: drgulrez2@gmail.com

Received: October 22, 2018, Accepted: December 04, 2018, Published: December 10, 2018

Status of heavy metals in different rivers

River Ganga and Yamuna at Allahabad

Ganga River is considered to be the most sacred river of the nation and consisting of many renowned views. Ganga has been included in the most polluted river of India. Pandey et al. evaluated heavy metals contamination of Ganga and Yamuna stretches in Allahabad. The heavy metals Chromium, Nickel, Lead Copper, Iron, and Zinc at all the sampling stations (Table 1) were detected above the allowed confines [20]. Heavy Metals were analyzed by atomic absorption spectoscopy at various wavelengths on all sampling stations. Another study conducted on 2014 indicated that from Sangam to Arail Ghat whole average value can be arranged as Fe > Co > Ni> Cu >Pb [21], (Table 2). In 2014 Yadav and Yadav conducted research on position of Heavy metal in various drains release into the River Ganga and gathering in soil and plant at Allahabad, Uttar Pradesh and monitored the level of contamination of heavy metals. (S.D–Standard deviation, C.V–Cofficient of Variation) (Table 3) [22].

River Ganga at Varanasi

The concentration of toxic heavy metals was reviewed in Ganga River at Varanasi due to its high degree of contamination and threat to human and animal health. Pandey et al. analyzed the concentration of heavy metals in 20 km stretch of the river. He found that the midstream of Ganga River at Varanasi is significantly polluted by heavy metals. The highest level of, Cu, Ni, Cd, Cr and Pb was found in winter while Zinc was detected highest during summer season. This research showed an order Zn>Ni>Cr>Pb>Cu>Cd in Ganga at Varanasi. At downstream sampling points all the heavy metals were found to be increased in concentration (Table 4). In another assessment performed in 2017 on Ganga River shown that levels of Cr, Pb, Ni, Cu, and Cd went beyond the WHO guidelines (Figure 1 and Table 5) [23].

An assessment had been done in 2016 on by pass bridge upstream, Assi Ghat, Dashswamedh Ghat, and Raj Ghat bridge downstream Varanasi, to carry out the collection and analyses of samples for Temperature, pH, concentrations of Cr, Ni, Cu, As, Cd, Pb in (μg. L^{-1}). The order of heavy metals contamination in the water was found as As>Pb>Cu>Ni>Cr>Cd. The levels heavy metals were found to be higher than the approved values by World Health Organization standards (WHO) and toxicity reference value (TRV) for fresh water proposed by USEPA except Ni. The Cr concentrations were detected elevated in March with the maximum value 23 μg. L^{-1} at Dashswamedh Ghat and with minimum value 5 μg. L^{-1} in January at Assi Ghat. The Ni concentrations were found elevated in March with the maximum value 30 μg. L^{-1} at Dashswamedh Ghat and with minimum value 12 μg. L^{-1} in January at Assi Ghat. At Assi Ghat the Cu concentrations were exceeded in March with the maximum value 30 μg. L^{-1} and with minimum value 9 μg. L^{-1} in January. The As was observed higher in March with the highest value 80 μg. L^{-1} at Raj Ghat downstream and lowest value 10 μg. L^{-1} in January at By pass bridge upstream. The Cd was elevated in March with the maximum value 21 μg. L^{-1} at Raj Ghat downstream and minimum value 0.9 μg. L^{-1} in January at by pass bridge upstream. The Pb concentrations were exceeding in March with the peak value 53 μg. L^{-1} at Raj Ghat and shortest value 9 μg. L^{-1} in January at by pass bridge upstream.

Singh in 2011 reported that the concentration of Pb found between 0.86 ppm and 0.04 ppm. Cd concentration was found from 0.051 ppm to 0.009 ppm. The Cr was detected from 0.072 to ppm –0.017 ppm. Maximum concentrations of Cu (0.168 ppm) and Pb (0.84 ppm) were found in Assi ghat sample, Cr (0.072) analyzed in Anandmayi ghat water sample, Cd (0.051 ppm) observed in Prabhu ghat water sample, Fe (1.981 ppm) found in Riwa ghat water sample. In general all water samples were found to possess the concentration of heavy metals in the order Fe>Cu>Pb>Cr>Cd. Fe concentration was detected more than acceptable limit. Cu concentration was found exceeding than permissible limit in all the samples excluding Nishadraj ghat, it lies as 0.168 ppm and 0.047 ppm. Only Mn and Zn were analysed under permissible limit in all water samples.

River Gomti at Lucknow

Lucknow being the capital of Uttar Pradesh state is consecrated by Gomti River. Vast expansion of some anthropogenic activities is continuously contaminating the water of Gomti. Sameer et al. studied before and after spring Seasonal Variation of some Heavy Metal contamination in Sediments of Gomti in the surrounding area of Lucknow, India. The study conducted for three successive years from 2009 to 2011 on heavy metals (As, Cu and Fe) in river bed settlements of Gomti River, Lucknow at chosen sites in before and after spring Season. Before spring season the level of various metals found between As: 0.07–0.7, Fe: 7462.00–7977.00, Cu: 10.98–36.73 μg g^{-1}. While As: 0.05–0.07, Fe: 543.00–7797.00, Cu: 32.00–9. 23 μg^{-1} detected for post–monsoon metal concentration. The concentration of Fe and As was observed insignificant to small level whereas Cu found from little to modest level (Table 6) [24].

Trivedi et al. to carry out the determination of physicochemical parameters, concentration of heavy metals and pesticide in Gomati River water in Lucknow to study the ecological balance. Different 5 locations from three sites were selected for sample collection from upstream to downstream (right, middle and left side of the river) of Lucknow. The analyses was conducted to detect the organochlorine pesticides (OCP's), herbicides and heavy metals like Ni, Cr Cu, Cd, Fe, Mn, Zn, Pb (Figure 2 and Table 7) [25].

River Ram Ganga at Moradabad

At Moradabad Ramganga river water in a 25 km stretch has also been selected for pollution monitoring in this review article. Since Moradabad a brass city of India is situated near Ramganga River. A number of brass industries are constantly releasing their waste into the river. The water quality with special reference to heavy metals was observed, although this tributary still required the scope of research. Few studies conducted on Ramganga at Moradabad indicate the extent of pollution of the river. The toxicity of heavy metals is found high at the point of effluent discharge and declined gradually on distant from discharge point. (Figure 3 and Table 8). The enlisted metals found in industrial discharge are constantly settling in Gangan River (Tributary of Ramganga), Moradabad. As a consequence, these metals polluted the river system badly and exert serious lethal effect on river existence [26]. The research conducted by UP council for Agriculture Research (UPCAR) declared that Ramganga is most polluted at Moradabad and contaminated due to mixing of heavy metals by untreated discharge effluent of industries.

In another study the stage of contamination was observed to be highest at

TABLE 1

Acceptable values of various heavy metals in drinking water in mg/l [28]

Heavy metal	CPCB Central Pollution Control Board	USEPA United States Environmental Protection Agency	ISI Indian Standard Institution	WHO World Health Organization	ICMR Indian Council of Medical Research
Iron	1.0	--	0.3	0.1	1.0
Cupper	1.5	1.3	0.05	1.0	1.5
Mercury	No relaxation	0.002	0.001	0.001	0.001
Cadmium	No relaxation	0.005	0.01	0.005	0.01
Arsenic	No relaxation	0.05	0.05	0.05	0.05
Lead	No relaxation	--	0.10	5.0	0.05
Zinc	15.0	--	5.0	5.0	0.10
Chromium	No relaxation	--	0.05	0.1	--

TABLE 2

Heavy metal concentrations (mg/l) in water of the Allahabad river basin [21]

Sites	Heavy metal concentration (mg/l)					
	Cr	Cd	Ni	Fe	Pb	Mn
Old Bridge W1	0.29 ± 0.005	0.29 ± 0.0050	234 ± 0.00099	1.223 ± 0.0289	0.254 ± 0.0167	0.010 ± 0.0054
Arail Ghat W2	0.16 ± 0.0075 0	0.33 ± 0.0013	0.345 ± 0.0093	1.939 ± 0.0494	0.284 ± 0.0525	0.013 ± 0.0127
Sangam W3	0.13 ± 0.0041 0	0.027 ± 0.0020	0.094 ± 0.0014	0.536 ± 0.0087	0.248 ± 0.0020	0.036 ± 0.0149
Saraswati Ghat W4	0.003 ± 0.0094 0	0.020 ± 0.0009	0.060 ± 0.0025	1.109 ± 0.0159	0.166 ± 0.0387	0.055 ± 0.0017

TABLE 3

Heavy metal concentrations (mg/l) in water of the Allahabad river basin [22]

Sites	Seasons	Heavy metal concentration (mg/l)				
		Fe	Cd	Pb	Zn	Cu
Mori gate drain	Winter	0.486	0.005	0.005	0.093	0.006
	Summer	0.498	0.006	0.007	0.095	0.009
	monsoon	0.495	0.004	0.004	0.094	0.007
Mawaiya drain	Winter	0.253	0.033	0.039	0.053	0.015
	Summer	0.257	0.036	0.042	0.056	0.019
	monsoon	0.249	0.028	0.035	0.049	0.018
Bairagiya drain	Winter	0.491	0.005	0.004	0.092	0.007
	Summer	0.494	0.006	0.005	0.093	0.008
	monsoon	0.490	0.004	0.004	0.091	0.005

TABLE 4

Heavy metals concentration (mg/l) at various sites of Ganga at Varanasi [29]

Sample stations	Cd	Cr	Cu	Ni	Pb	Zn
Adalpura	0.78 ± 0.05	0.48 ± 0.03	2.25 ± 0.16	0.31 ± 0.02	3.60 ± 0.24	152.70 ± 11.45
Bypass upstream	11.78 ± 0.76	5.20 ± 0.35	36.90 ± 2.66	4.20 ± 0.31	59.50 ± 4.12	332.70 ± 2.50
Bypass downstream	16.25 ± 1.02	6.11 ± 0.38	47.85 ± 3.10	5.31 ± 0.29	84.95 ± 6.30	369.48 ± 2.69
Samne Ghat	13.27 ± 0.67	6.00 ± 0.33	42.66 ± 2.92	5.05 ± 0.33	78.24 ± 5.22	337.15 ± 2.94
Ravidas Park	12.00 ± 0.68	6.25 ± 0.35	57.66 ± 4.55	4.15 ± 0.28	75.50 ± 6.32	298.1 ± 16.52
Assi Ghat	13.65 ± 0.84	6.10 ± 0.47	44.85 ± 3.35	5.10 ± 0.31	76.95 ± 4.69	345.20 ± 3.15
Dandi Ghat	10.50 ± 0.72	5.33 ± 0.26	63.56 ± 4.95	5.55 ± 0.31	77.96 ± 6.51	316.3 ± 18.61
Dashaswamedh Ghat	12.92 ± 0.93	5.89 ± 0.38	45.18 ± 2.96	4.96 ± 0.27	81.56 ± 5.38	319.40 ± 2.66
Manikarnika Ghat	10.17 ± 0.67	4.50 ± 0.23	61.43 ± 4.27	5.26 ± 0.41	84.56 ± 6.20	317.1 ± 30.10
Lal Ghat	10.07 ± 0.62	6.00 ± 0.35	67.16 ± 4.57	5.80 ± 0.35	85.33 ± 6.41	318.45 ± 26.05
Raj Ghat upstream	18.65 ± 1.26	6.27 ± 0.44	57.33 ± 3.76	5.78 ± 0.32	107.34 ± 7.85	447.50 ± 3.18
Raj Ghat downstream	18.26 ± 1.39	6.28 ± 0.39	57.68 ± 4.15	5.90 ± 0.37	106.90 ± 9.26	440.61 ± 3.24

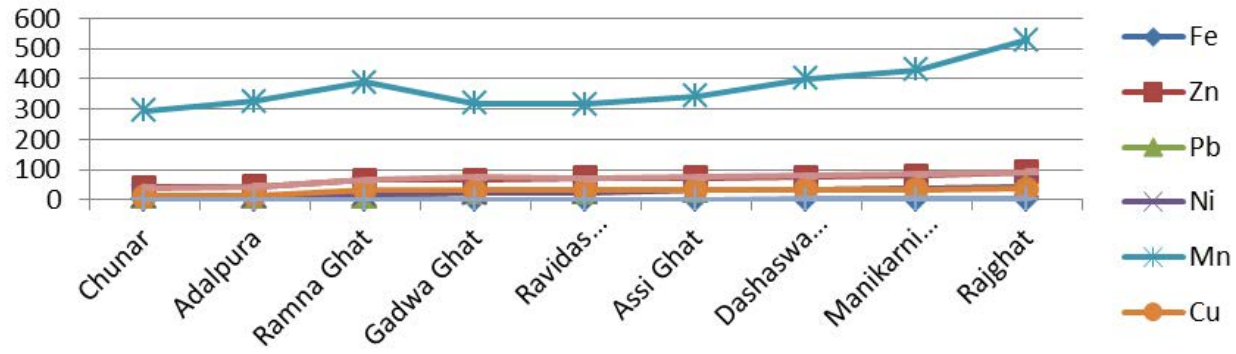

Figure 1) *Concentration of heavy metal as atmospheric depositions at river sites of Varanasi*

the convergence with Gangan, its tributary. The river water was found to possess some toxic heavy metals like Cu, Cr, Zn, Ni, Fe and Pb. The Cu and Cr detected beyond the allowed limits at some downstream points of the river. The Fe content was exceeding the permissible limit all through the river stretch. Zn and Pb were found to be within acceptable limits whereas the concentration Ni was found negligible (Figure 4).

Pollution studies on Ramganga River at Moradabad [27]. The data of status of heavy metals is averaged and compared with all the five rivers of Uttar Pradesh. The outcome of different analyses is summarised in the 5 graphical representation of status of heavy metals in all the five rivers. It is quite obvious from the above discussion that the Ganga River at Allahbad and at Varanasi followed by Gomti river are most polluted rivers of the state. In all the rivers the concentration of heavy metals are exceeding from normal range and causing the threat to the health and well–being of dependent population across the stretch [28–35].

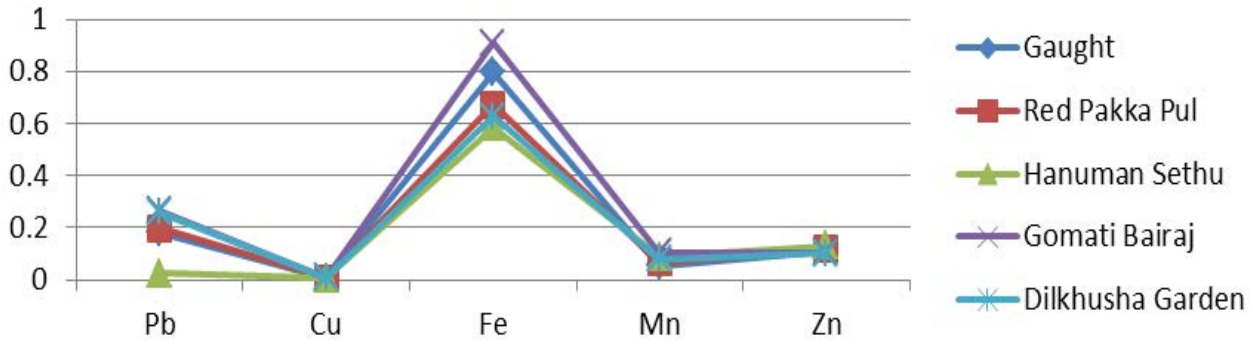

Figure 2) *Level of heavy metals in various sites of Gomati River at Lucknow*

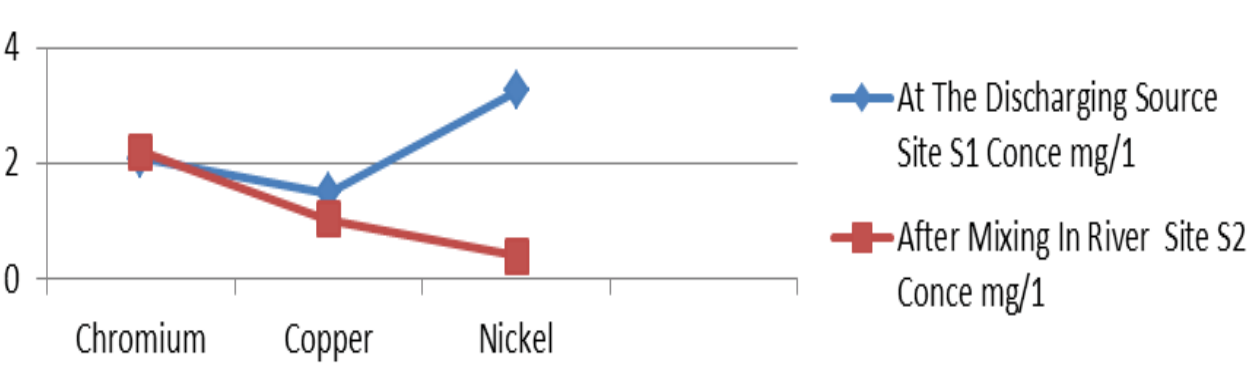

Figure 3) *Concentration of Cr, Cu and Ni in industrial discharge flowing in Gagan river (mg/lit)*

TABLE 5

Atmospheric depositions of heavy metals (mg/l) at selected river sites of Varanasi [23]

S. No	Sampling sites		Fe	Zn	Pb	Ni	Mn	Cu	Cd	Cr
		Mean	21,924.07	41.05	10.94	11.77	296.02	12.71	0.94	39.05
1.	Chunar	SD	11,902.05	6.15	2.26	2.34	97.11	1.56	0.26	4.71
		EF	--	0.71	0.88	0.47	0.32	0.43	3.16	0.48
		Mean	25,028.80	44.01	11.71	14.06	326.40	14.33	1.07	43.40
2.	Adalpura	SD	10,096.72	7.43	2.52	3.89	63.44	1.52	0.33	4.57
		EF	--	0.67	0.82	0.49	0.31	0.42	3.14	0.47
		Mean	28,723.93	65.56	13.17	17.39	389.75	33.61	1.24	66.04
3.	Ramna Ghat	SD	13,241.11	9.80	2.53	4.13	128.93	2.27	0.38	11.57
		EF	--	0.87	0.81	0.53	0.32	0.86	3.16	0.56
		Mean	30,464.93	66.45	24.02	23.22	318.49	33.25	1.43	74.71
4.	Gadwa Ghat	SD	12,418.66	9.75	6.48	5.34	57.57	6.54	0.49	7.80
		EF	--	0.83	1.38	0.67	0.25	0.80	3.45	0.60
		Mean	32,132.67	70.11	28.17	25.92	316.81	34.18	1.65	70.23
5.	Ravidas Park	SD	--	11.02	6.23	4.766	70.69	9.52	0.60	7.88
		EF	13,268.96	0.83	1.54	0.71	0.23	0.78	3.79	0.59
		Mean	33,925.07	73.80	33.15	31.49	342.46	33.95	1.95	76.58
6.	Assi Ghat	SD	13,843.86	11.67	8.70	8.12	70.71	14.04	0.65	6.38
		EF	--	0.83	1.72	0.82	0.24	0.74	4.22	0.61
		Mean	35,128.93	75.85	34.37	34.93	399.98	34.22	2.15	79.95
7.	DashashwamedhGhat	SD	14,691.92	12.35	9.55	7.73	55.99	14.59	0.85	6.63
		EF	--	0.82	1.72	0.87	0.27	0.72	4.50	0.61
		Mean	39,398.87	80.53	39.64	38.49	429.41	34.85	2.22	86.25
8.	Manikarnika Ghat	SD	17,938.39	13.84	11.74	7.80	40.35	16.14	0.87	6.16
		EF	--	0.78	1.77	0.88	0.26	0.65	4.13	0.58
		Mean	41,170.13	92.48	44.89	43.02	529.08	36.68	2.86	93.28
		SD	20,661.64	23.37	15.30	11.43	57.46	15.97	1.04	4.51
9.	Rajghat	EF	--	0.86	1.92	0.92	0.30	0.65	5.10	0.61
		%EF	52.29	51.93	46.34	47.77	32.62	71.10	40.79	56.96

TABLE 6

Concentration of heavy metals (mg/l) in sediment of Gomti River in Lucknow city

Sampling Sites	Arsenic	Iron	Copper	Season and year
Sitapur over bridge (Inlet)	0.593 ± 0.02	6300.00 ± 126.0	10.98 ± 0.21	
Kudiaghat	0.643 ± 0.03	6425.00 ± 54.25	20.23 ± 1.02	
Hanuman setu	0.675 ± 0.05	6503.00 ± 96.09	25.85 ± 1.29[a]	
Laxmanmela park	0.722 ± 0.01[a]	5563.00 ± 78.56	23.63 ± 0.47	pre-monsoon 2009
Saheed park	0.611 ± 0.02	5401.00 ± 89.54	23.12 ± 0.69	
Dilkhusha railway over bridge	0.523 ± 0.01	7462.00 ± 44.95[a]	21.53 ± 0.43	
Sitapur over bridge (Inlet)	0.632 ± 0.032	5300.00 ± 116.0	10.54 ± 0.31	
Kudiaghat	0.651 ± 0.014	5332.00 ± 229.8	15.21 ± 0.95	
Hanuman setu	0.532 ± 0.024	5431.00 ± 104.6	29.03 ± 0.87[a]	
Laxmanmela park	0.522 ± 0.020	5264.00 ± 107.4	21.31 ± 0.53	post-monsoon 2009
Saheed park	0.531 ± 0.010	5093.00 ± 101.8	19.05 ± 0.49	
Dilkhusha railway over bridge	0.653 ± 0.026[a]	5384.00 ± 203.2[a]	20.43 ± 0.61	
Sitapur over bridge (Inlet)	0.523 ± 0.008	6485.00 ± 97.06	12.73 ± 0.04	
Kudiaghat	0.72 2 ± 0.067	7795.00 ± 54.89	14.54 ± 0.06	
Hanuman setu	0.713 ± 0.081	6925.00 ± 74.56	36.73 ± 2.74[a]	
Laxmanmela park	0.725 0 ± 0.071	5758.00 ± 43.97	25.84 ± 1.43	pre-monsoon 2010
Saheed park	0.744 ± 0.053	5975.00 ± 98.32	25.872 ± 1.94	
Dilkhusha railway over bridge	0.793 ± 0.029	7957.00 ± 80.21[a]	29.93 ± 2.59	
Sitapur over bridge (Inlet)	0.431 ± 0.004	4980.00 ± 134.75	9.73 ± 0.03	
Kudiaghat	0.5173 ± 0.001	5125.00 ± 21.43	19.23 ± 0.53[a]	
Hanuman setu	0.5621 ± 0.001	5362.00 ± 37.84	23.23 ± 0.69	
Laxmanmela park	0.5438 ± 0.01	4954.00 ± 75.96	23.74 ± 0.43	post-monsoon 2010
Saheed park	0.564 ± 0.002	4834.00 ± 86.21	22.153 ± 0.26	
Dilkhusha railway over bridge	0.487 ± 0.002[a]	6753.00 ± 53.97[a]	19.29 ± 0.75	
Sitapur over bridge (Inlet)	0.423 ± 0.008	6485.00 ± 97.06	12.73 ± 0.04	
Kudiaghat	0.62 2 ± 0.067[a]	6795.00 ± 54.89	16.54 ± 0.06	
Hanuman setu	0.711 ± 0.081	6905.00 ± 44.16	26.73 ± 2.74	pre-monsoon 2011
Laxmanmela park	0.73 0 ± 0.076	5761.00 ± 43.17	25.84 ± 1.43	
Saheed park	0.763 ± 0.053	5975.00 ± 98.32	25.87 ± 1.94	
Dilkhusha railway over bridge	0.798 ± 0.021	7977.00 ± 89.21[a]	29.93 ± 2.59[a]	
Sitapur over bridge (Inlet)	0.501 ± 0.003	5321.23 ± 0.014	13.94 ± 0.03	
Kudiaghat	0.540 ± 0.001[a]	5433.12 ± 0.018	14.13 ± 0.02	
Hanuman setu	0.509 ± 0.01	4783.21 ± 0.011[a]	28.13 ± 3.01	post-monsoon 2011
Laxmanmela park	0.503 ± 0.01	4331.22 ± 0.016	28.56 ± 3.04	
Saheed park	0.548 ± 0.01	4101.21 ± 0.003	29.93 ± 3.05	
Dilkhusha railway over bridge	0.408 ± 0.02	4321.32 ± 0.005	32.11 ± 3.04	

TABLE 7

Heavy metal Concentration at selected sites of Gomati River water

Metal	Gaught		Red Pakka Pul		Hanuman Sethu		Gomati Bairaj		Dilkhusha Garden	
	Mean	range(µg/ml)	Mean	range(µg/ml)	Mean	range(µg/ml)	Mean	range(µg/ml)	Mean	range(µg/ml)
Pb	0.182	(0.167-0.191)	0.199	(0.190-0.215)	0.0231	(0.211-0.262)	0.264	(0.221-0.337)	0.260	(0.254-0.266)
Cu	0.006	(0.004-0.010)	0.006	(0.005-0.008)	0.0051	(0.004-0.006)	0.008	(0.004-0.016)	0.008	(0.007-0.008)
Fe	0.798	(0.595-1.180)	0.672	(0.654-0.704)	0.587	(0.544-0.612)	0.908	(0.841-1.017)	0.626	(0.502-0.695)
Mn	0.054	(0.044-0.072)	0.065	(0.062-0.068)	0.088	(0.075-0.109)	0.103	(0.098-0.112)	0.078	(0.074-0.084)
Zn	0.110	(0.07-0.168)	0.118	(0.171-0.191)	0.130	(0.081-0168)	0.104	(0.046-0.18)	0.100	(0.077-0.115)

TABLE 8

Concentration of Cr, Cu and Ni in industrial discharge flowing in Gagan river (mg/lit)

Trace Metal	At The Discharging Source (Conc. in mg/l) Site S1	After Mixing In River (Conc. in mg/l) Site S2
Chromium	2.082	2.19
Copper	1.492	1.03
Nickel	3.248	0.39

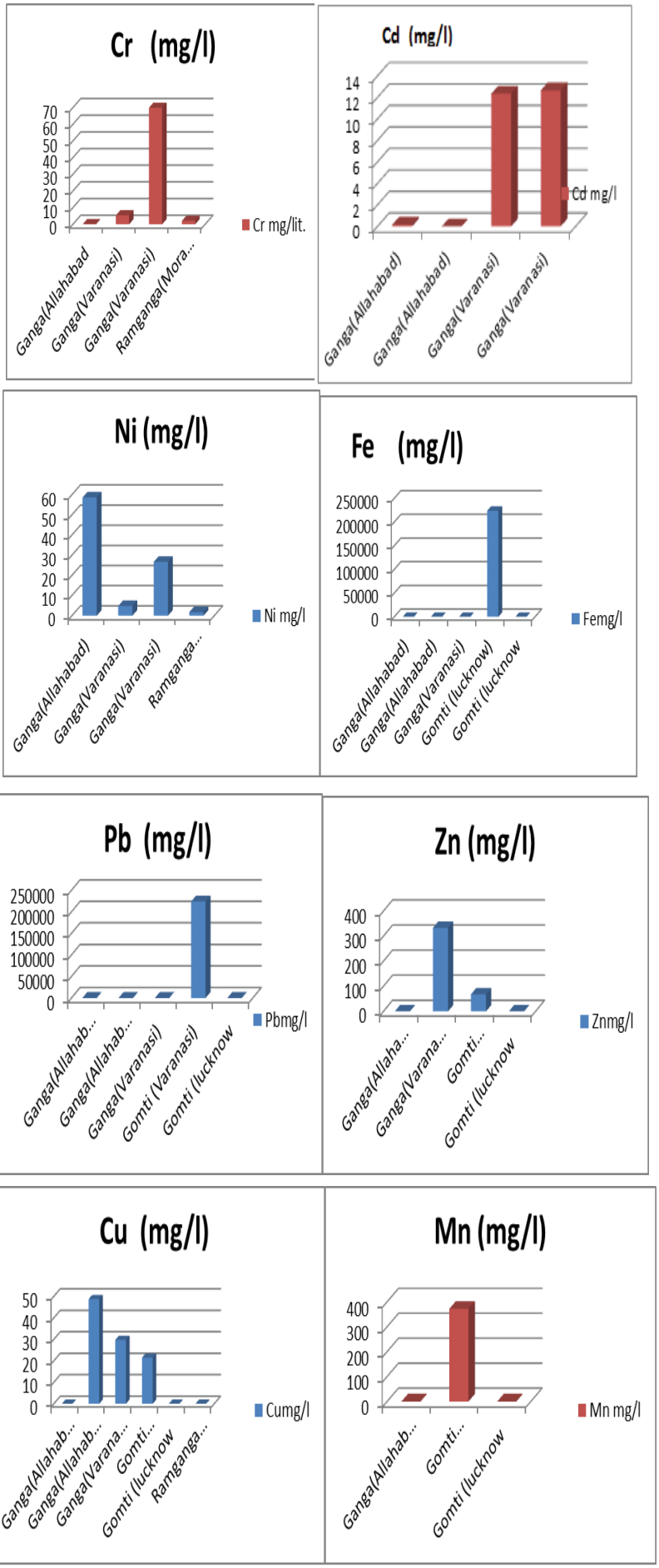

Figure 4) *Graphical representation of variation of heavy metals at certain sites in all rivers*

DISCUSSION AND CONCLUSION

This review article aimed to through light upon the present state of extent of pollution in the river Ganga, Yamuna, Gomti and Ram Ganga due to the presence of heavy metals. Numerous researches conducted on heavy metal pollution on these rivers show that the concentration of heavy metals in these selected rivers and sediment are exceeding the permissible concentrations, which penetrate the stream, through straight discharges of municipal, industrial and mining effluents as discussed in this paper. The toxic metals are not only badly affecting the human health by causing severe diseases but also creating the imbalance of the aquatic ecosystem of rivers Ganga, Yamuna, Gomti and Ram Ganga. Since protection and management plan of River Ganga is going on a large scale by Government of India but still there is a need of attention towards other rivers like Gomti and Ramganga. Therefore the conservation and supervision strategies are suggested for the contaminated sites of Gomti and Ramganga as well as there is an urgent needed to implement the preservation and awareness plan of River Ganga at both the mentioned sites. All these rivers should be monitored closely and necessary actions should be taken which undoubtedly are the blessings for whole mankind especially for all the citizens of Uttar Pradesh, India.

REFERENCES

1. CPCB, Status of Water Quality in India. Central pollution Control Board. 2004.
2. Zhang J, Huang WW. Dissolved trace metals in Huanghe: The most turbid large river of the world. Water Res. 1993;27(1):1–8.
3. Ammann A, Michalke B, Schramel P. Speciation of heavy metals in environmental water by ion chromatography coupled to ICP-MS. Anal Bioanal Chem. 2002;372:448–52.
4. Das RK, Bhowmick S, Ghosh SP, et al. Coliform and fecal coliform bacteria load in a stretch of hoogly. In Vass KK and Sinha M (Eds.), proceedings of the national seminar on changing perspectives of Inland Fisheries Society of India, Barrackpore. 1997;pp:41–5.
5. Ghosh S, Vass KK. Role of sewage treatment plant in Environmental Mitigation. In Vass KK and Sinha M (Eds.), proceedings of the national seminar on changing perspectives of Inland Fisheries Society of India, Barrackpore. 1997;36–40.
6. Karan SK, Harada H. Surface water pollution in three urban territories of Nepal, India and Bangladesh. Environ Manage. 2001;28(4):483–96.
7. Jain VK. Studies on effect of cadmium on the growth pattern of *Phaseolus aurius* varieties, Absi I. Bot Conf JIBS. 1978;pp:57–84.
8. Kansal A, Siddiqui NA, Gautam A. Assessment of heavy metals and their interrelation ship with some physicochemical parameters in E co-efficient Rivers of Himalayan Region. Int J Envron Sci. 2011;2:452–62.
9. Bruins MR, Kapil S, Oehme FW. Microbial Resistance to metals in the environment. Ecotoxicol Environ Saf. 2000;45:198–207.
10. Abbasi SA, Abbasi N, Soni R. Heavy metal in the environment, New Delhi. 1998;p:225
11. Woo NC, Choi MJ. Arsenic and metal contamination of water resources from mining wastes in Korea. Environ Geol. 2001;40(3):305–11.
12. Earman S, Ronald L. Hershey water quality impacts from waste rock at a carlin-type gold mine, Elko country, Nevada. Environ Geol. 2004;45:1043–53.
13. Oliveira A, Palma C, Valença M. Heavy metal distribution in surface sediments from the continental shelf adjacent to Nazaré canyon. Deep Sea Res Part 2 Top Stud Oceanogr. 2011;58:2420–32.
14. Milu V, Leroy JL, Peiffert C. Water contamination downstream from a copper mine in the Apuseni Mountains Romania. Environ Geol. 2002;42:773–82.
15. Hammarstrom JM, Seal RR, John AL, et al. Weathering of sulfidic shale and copper mine waste: Secondary minerals and metal cycling in Great Smoky Mountains National park, Tennessee and North Carolina, USA. Environ Geol. 2003;45:35–57.
16. Reis AP, Patinha C, Ferreira DS, et al. Metal fractionation of cadmium, lead and arsenic of ceogenic origin in top soils from the Marrancos gold mineralisation, northern Portugal. Environ Geochem Health. 2011;34(2):229–41.
17. Conaway, Cameron. The Ganges River is dying under the weight of Modern India. Newsweek Retrieved. 2017.
18. Flyn R. Holy literary license: The almighty chooses Fallible Mortals to write, edit and translate godstory. Wings Press. 2017;p:96.
19. Wohl, Ellen E. A world of rivers: Environmental change on ten of the world's great rivers. Chicago: University of Chicago Press. 2012.
20. Pandey A, Ramteke PW, Verma OP. Evaluation of heavy metals loading of rivers ganga and yamuna. Int J Pharm Bio Sci. 2013;4(3):1410–17.
21. Syed S, Naushad, Alok ML. Determination of heavy metals in water of ganga and yamuna. Int J Cur Res. 2014;11:10131–33.
22. Yadav A, Yadav PK. Heavy metal status in different drains discharge into the River Ganga and accumulation in land and plant at Allahabad, Uttar Pradesh. J Exp Biol. 2014;4(5):53–7.
23. Pandey J, Singh R. Heavy metals in sediments of Ganga River: Up- and downstream urban influences. Appl Water Sci. 2017;7:1669–78.
24. Sameer, Chandra, Sanjay, et al. Pre and post-monsoon seasonal variation of some heavy metal pollution in sediments of river Gomti in the vicinity of Lucknow City, India. J Appl Sci Environ Manage. 2017;21(3):593–9.
25. Trivedi P, Singh A, Srivastava A, et al. An assessment of water quality of Gomati River particular relevant to physicochemical characteristics, pesticide and heavy metal. Int J Eng Res Appl. 2016;6:66–75.
26. Agarwal A, Agarwal M. Effect of heavy metals on aquatic life in Gangan River at Moradabad, Uttar Pradesh, India. Int J Adv Res. 2014;2:250–4.
27. Sharma SD, Pandey KS. Pollution studies Ramganga River at Moradabad River, physic-chemical characteristics and toxic toxic metals. Pollut Res. 1998;17:201–09.
28. Kumar M, Puri A. A review of permissible limits of drinking water, Indian. J Occup Environ Med. 2012;16:40–4.
29. Pandey J, Shubhashish K, Richa P. Heavy metal contamination of Ganga river at Varanasi in relation to atmospheric deposition. Trop Ecol. 2010;51(2):365–73.
30. Megha A. River water pollution assessment of Gangan river in Moradabad, Uttar Pradesh. Int J Res Anal Rev. 2017;167:1269-2348.
31. Merrington G, Alloway BJ. The transfer and fate of Cd, Cu, Pb and Zn from two historic metalliferous mine sites in the U. K. Appl Geochem. 1994;9:677–87.
32. Thornton I. Geochemical aspects of heavy metal pollution and agriculture in England and Wales. In org Pollut Agri. 1980;326:105–25.
33. Pestana MHD, Formoso MLL, Teixeira EC. Heavy metals in stream sediments from copper and gold mining areas in southern Brazil. J Geochem Explor. 1997;58:133–43.
34. CPCB. Most polluted rivers in the world: These are the worst 11 take part, take part. 2017.
35. Fuge R, Paveley CF, Holdham LN. Heavy metal contamination in the Tanat Valey, North Wales. Environ Geochem Health. 1989;11:127–35.