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Heavy Metal Pollution in Chapra (Bihar)

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ABSTRACT

River water at 7 sampling sites were examined to evaluate different concentrations of four heavy metals and with using indices also Heavy Metal Pollution Index (HPI); Heavy Metal Evaluation Index (HEI) and Contamination index (Cd) determined in this study. The average concentrations in parts per billion in the increasing order were Cu (292.7)> Fe (309.23) > Mn (475.15) >Zn (3643.9). Resultant average values of HPI 551.40, HEI 12.07 and Cd 8.07 based on metal concentration were obtained.

Keywords: Heavy Metal Pollution Index (HPI), Heavy Metal Evaluation Index (HEI), Contamination Factor (Cd).

INTRODUCTION

The Saryu river is one of the most sacred and important river of India. It is basically Ghaghra river but at Ayodhya it is called Saryu river due to historical reason. It is seen that various variety of domestic sewage and dirty water is released into the Saryu River which causes various type of pollution causing serious problem on human health and natural balance too. So it is necessary as we feel to assess the pollution in above two sacred places. It is seen that nearly no attention has been given to water quality measurement of Saryu river.

There several studies have focused on heavy metal pollution of water resources all around the world (Wang et *al,* 2014; Zhang et *al,* 2012; Nasrabadi et *al,* 2010). The water quality monitoring of River Yamuna has indicated a significant presence of several heavy metals in its water (CPCB, 2006; Jain, 2009; Kaur and Mehra, 2012).

The integration of Heavy Metal Pollution Index, Heavy Metal Evaluation Index and Contamination index (Swanson et *al,* 2001; Vieira et *al*, 2012; Mohan et *al*, 1996; Edet and Offiong 2002; Prasad and Mondal 2008) provides detailed, quick, and reliable information for decision-makers to adopt or implement strategies related to water pollution and scarcity (Rawat and Singh, 2018).

MATERIALS AND METHODS

The district of Saran is situated between $25^0$36'and $26^0$13' North latitude and $84^0$24'and $85^0$15' East longitude in the southern part of the north Bihar. The geographical area of the district is 2641 square km. The total population of the district is 39, 43,098 (2011census) and population density increase 1231 to 1500 per square km. The Saryug (Ghaghara) constituting a natural boundary of south part of Chapra town. The Saryug River passes through the southern part of the Chapra town. Thousands of people survive and do their livelihood on the bank of this river. A large number of people are totally depend on the river water and fishes e.g. fisheries and farming on the river bank.

The water samples were collected from the river with evident point sources of pollution in the satellite imageries and concentrations of anthropogenic activities. Two sets of sterilized High-Density Polyethylene Bottle (HDPE) with a capacity of 500 ml each were filled from a 20cm river water depth. In-situ parameters (pH, Temperature,

Total Dissolved Solids, Electric Conductivity, Dissolved Oxygen, Turbidity) were measured using a Horiba Multi-parameter probe. The samples preserved at 4°C after acidifying with concentrated Nitric Acid were transferred to the laboratory for further analysis as per the standard procedure. The Atomic Absorption Spectrophotometer (AAS) was used for Heavy Metal detection of Iron, Zinc, Manganese, and Copper and an average of three replicates were recorded.

The Heavy Metal Pollution Index (HPI) values evaluated by Equation (Mohan et *al*, 1996; Ichwana et *al*, 2016) in the form of weighted arithmetic averages of the concentrations as:

$$HPI = \sum_{i=1}^{n} W_i \qquad (1)$$

Wherein, Wi is the unit weightage defined as the reciprocal value of Si which is the maximum permissible limit for irrigation purposes of water as per FAO (1972). The number of parameters n and Qi being the sub-index of the i^{th} parameter are calculated as in Equation 2. Further, Mi has monitored values of the heavy metal and Si the standard value for the i^{th} parameter. Both these values are in ppm.

$$Q_i = \sum_{n=1}^{n} \frac{M_i}{S_i} * 100 \qquad (2)$$

Further Heavy Metal Evaluation Index (HEI) is used to obtain the overall quality of water concerning the heavy metal concentrations measured.

$$HEI = \sum_{i=0}^{n} Hc / Hmac$$

Wherein, Hc and Hmac are the monitored value and maximum admissible concentration (mac) of the ith parameter (Pundir et *al*, 2018). Table 3 was used for the calculation of the HPI and HEI.

The Contamination index (Cd) analyzes the cumulative effect of various parameters on the quality of water for domestic purposes. This index is the sum of contamination factors of the individual parameters beyond their permissible standard values as represented in Eqn. below.

$$Cd = \sum_{i=1}^{n} Cfi$$

Where *Cfi* = *CAi/CNi*-1. The Cfi, CAi, and CNi represent the contamination factor, analytical value, and upper permissible concentration, respectively, of the i^{th} component. N denotes the 'normative value'; values for CNi were taken as MACs given in Table 1.

Table 1: Permissible Heavy Metals quantity by World agencies and Standard values for the indices computation

Heavy metals	USEPA (µG/L)	BIS 2012	ICMR 1975	CPCB 2012	W	S	I	MAC
Fe	300	300	300	300	0.005	300	200	200
Zn	5000	5000	5000	5000	0.002	5000	3000	5000
Mn	50	100	100	2000	0.02	100	500	50
Cu	1300	50	50	3000	0.001	1000	2000	1000

The above table describes desirable amount of heavy metals which may not showed acute and chronic toxicity in human population and even a little rise can showed detrimental effects in the case of direct and indirect use of such water in any climatic regions.

OBSERVATION

The derived results are summarized in Table 2 with average concentrations of the heavy metals, total metal load at the sites and the physical parameters measured namely pH, Temperature, and Total Dissolved Solids. The pH values range 6.31-7.86 with the average temperature being 20.7^{0}C. The average Total Dissolved Solids (TDS) was 348.71 ppm with a maximum of 885 ppm at Chapra town site and a minimum of 79 at Siswan site. The river sites showed variable heavy metal concentrations in Saryug river during this research period as indicated in figure 1.

Table 2: Site wise Physical and Heavy Metal Concentration load of River Saryug

Site No.	pH	Temp (°C)	TDS (ppm)	Cu (ppb)	Fe (ppb)	Mn (ppb)	Zn (ppb)	Metal load (ppb)
1	7.86	19.8	79	23.2	65.9	215	312.2	616.3
2	7.30	19.7	175	71.2	217.2	260	325.1	873.5
3	7.44	21	184	122.8	286.6	117.4	280.3	807.1
4	7.53	21	247	83.0	354.8	121.7	299.7	859.2
5	7.21	20.5	312	45.4	287.2	259.6	307.5	899.7
6	6.31	19.8	885	194.1	285.3	319.7	286.7	1085.8
7	7.20	19.8	559	118.9	291.6	375.4	313.4	1099.3

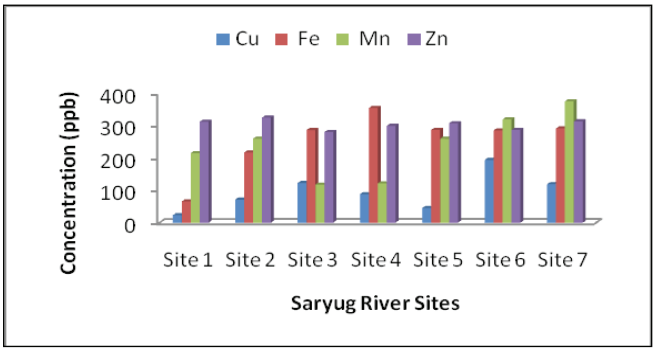

Figure 1: Mean Heavy metal concentrations (ppb) at Saryu River Sites

The river sites showed pH influencing HEI and Cd water quality indices in Saryu river during this research period as indicated in figure 2.

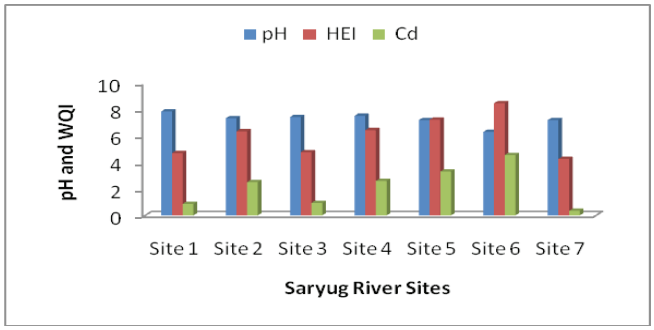

Figure 1: Water quality indices (HEI and Cd) in Saryu river

The Site wise results of the three indices: HPI; HEI; Cd for the study area are compiled in Table 3.

Table 3: Stepwise findings of the three Indices (HPI, HEI and Cd) for the study sites

Site No.	HPI	HEI	Cd
1	186.62	4.71	0.87
2	184.86	6.36	2.52
3	173.72	4.78	0.94
4	259.07	6.45	2.61
5	312.58	7.24	3.32
6	370.29	8.48	4.56
7	73.82	4.27	0.35

The mean values of the indices are HPI as 222.99; HEI as 6.04 and Cd as 2.16. Further, the correlation of the three indices with metal concentrations being studied to a significant level of >0.5 was noted in Table 4.

Table 4: Correlation analysis of the studied metal concentrations and Indices

Metal/Indices	HPI	HEI	Cd
Cu	0.28481	0.232458	0.232459
Fe	-0.13783	-0.17127	-0.17127
Mn	0.982294	0.991675	0.991675
Zn	0.324083	0.409166	0.409166
HPI	0.87	0.991036	0.991036
HEI	0.991036	1	0.991036
Cd	0.991036	1	1

A highly positive correlation of Manganese with the three indices was observed. Iron showed a negative correlation with the indices.

DISCUSSION

The results indicated the possible sources of contamination through untreated municipal and industrial waste; domestic effluents brought by the major drains in the Saryug river in Bihar segment and the dispersed agricultural runoff from the farmland. The agricultural runoff containing fertilizers, the wastage water drainage, leakages through Sewage Treatment Plants, laundry activities, immersions of idols, and sacred offerings together contributed to a high index value. Suggestions include checks measures on discharge of untreated domestic and industrial waste, reduction in fertilizers consumption while promoting organic techniques, separate ponds for idols immersion and sacred offerings. This is essential to standardization of domestic waste disposal, agricultural and underdone sewage runoff into the river more meticulously.

The HPI values between 0-25 are considered to be very good and progressively degrade above 75. The critical value is considered to be 100. Bhardwaj et *al* (2017) had 6 sites alike this study in Delhi; with overall heavy metal pollution index value calculated as 1492. In this study, the HPI was maximum at site 6 with 370.29. Further, Pal et *al* (2017) studied the 2 sites is similar to this study wherein the distance of 67 km led to settling of metals in sediments and decreased the HPI value from the previous noted values. In terms of HEI 4.27 at site 7 which is also associated with least Cd of 0.35. With the help of HEI, the values of HPI and Cd were correlated.

The present study revealed heavy metal deposition in large amounts resulted with high Ph value during the study period. As supported by Aktar et *al* (2010) often a reduction in heavy metal toxicity is credited to high pH value. Similarly, Woji Creek studied by Orji et *al* (2019) had HPI noted as 329.358. Site-specific higher HPI values are in agreement with Pal et *al* and Bhardwaj et *al* (2017) for the Yamuna river stretch.

The confluence of the river with Chapra drain marked a variable range of metal concentration in Saryug river sites as minimum in rural area and maximum load in urban and industrial sites. From the above results, it is clear that the Siswan site reports the most pristine condition of the river with the least heavy metal pollution. The segment covering Chapra as Chapra town and Ribilganj were seen to be major sources of pollution as there is an intense increase in HPI values beyond the sites which were in alignment with Bhardwaj et *al* (2017).

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Declaration: *We also declare that there is no conflict of interest among authors, and all ethical guidelines have been followed during the present study.*

REFERENCES:

Aktar MW, Paramasivam M, Ganguly M, Purkait S and Sengupta D (2010): Assessment and occurrence of various heavy metals in surface water of Ganga river around Kolkata: a study for toxicity and ecological impact. Environ Monit Assess 160(1–4):207–213.

Arora J and Mehra NK (2009): Seasonal dynamics of zooplankton in a shallow eutrophic, man-made hyposaline lake in Delhi (India): role of environmental factors. Hydrobiologia 626:27–40.

Backman B, Bodis D, Lahermo P, Rapant S and Tarvainen T (1997): Application of a groundwater contamination index in Finland and Slovakia. Environ Geol 36:55–64.

Bhardwaj, R, Gupta, A and Garg JK (2017): Evaluation of heavy metal contamination using environmetrics and indexing approach for River Yamuna, Delhi stretch, India. Water Science, 31(1), 52–66.

CPCB Report (2013): Status of Water Quality in India, 2011. Monitoring of Indian National Aquatic Resources, Series: MINARS/35/2013-14. Pp. 1-212.

Edet AE and Ofong OE (2002): Evaluation of water quality pollution indices for heavy metal contamination monitoring. A study case from Akpabuyo-Odukpani area, Lower Cross River Basin (southeastern Nigeria). Geo J 57:295–304.

FAO (1972): Overall study of the messara plain. Report on study of the water resources and their exploitation for irrigation in eastern crete. FAO Report No. AGL:SF/GRE/31, Rome.

Ichwana I, Syahrul S and Nelly W (2016): Water Quality Index by Using National Sanitation Foundation-Water Quality Index (NSF-WQI) Method at KruengTamiang Aceh. 110–117.

Jain P (2009): Sick Yamuna, Sick Delhi-Searching a Correlation. PEACE Institute Charitable Trust, Delhi, India.

Kaur S and Mehra P (2012): Assessment of Heavy Metals in Summer & Winter Seasons in River Yamuna Segment Flowing through Delhi, India. Journal of Environment and Ecology, 3(1): 149-165.

Mohan SV, Nithila P and Reddy SJ (1996): Estimation of heavy metals in drinking water and development of heavy metal pollution index. J Environ Sci Health A Environ Sci Eng Toxicol Toxic/ Hazard Substances Environ Eng 31(2):283–289.

Nasrabadi T (2015): An index approach to metallic pollution in river waters. International Journal of Environmental Research, 9(1), 385–394.

Pal R, Dubey RK, Dubey SK and Singh AK (2017): Assessment of Heavy Metal Pollution through Index Analysis for Yamuna Water in Agra Region, India. International Journal of Current Microbiology and Applied Sciences, 6(12), 1491–1498.

Prasad B and Mondal KK (2008): The impact of filling an abandoned open cast mine with fly ash on ground water quality: a case study. Mine Water Environ 27(1):40–45.

Pundir S, Singh R, Singh P, Aswal R and Kandari V (2018): Water Quality Indices for Asessing Heavy Metals Contamination in Drinking Water Sources of Lachchiwala Gram Panchayat, Dehradun. International Journal of Research in Advent Technology, 6(5), 708-714.

Rawat KS and Singh SK (2018): Water Quality Indices and GIS-based evaluation of a decadal groundwater quality. Geology, Ecology, and Landscapes, 2(4), 240–255.

Swanson S, Bahr J, Schwar M and Potter K (2001): Two-way cluster analysis of geochemical data to constrain spring source waters. Chem Geol 179:73–91.

Vieira JS, Pires JCM, Martins FG, Vilar VJP, Boaventura RAR and Botelho CMS (2012): Surface water quality assessment of Lis River using multivariate statistical methods. Water Air Soil Pollut 223:5549–5561.

Wang, Y, Xu HM and Cheng BY (2014): Influences of precipitation change on the runoff change in the Fujiang River basin during the period of 1951-2012. Progressus Inquitiones De Mutatione Climatis, 10(2): 127-134.

Zhang LY (2012): Research on the Effect of the Construction of QingyiFujiang Grand Bridge on the Fujiang River Concentration Field. Chengdu: Master Degree Thesis of Southwest Jiaotong University, China.