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A Review on Heavy Metal Pollution of River Ganga in India

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Abstract-

Indian people consider Ganga River as a holy river. The river provide water for survival of humans on earth. Water quality has become major issue because of growing industrial and urban development. Due to the sewage discharge and many other anthropogenic activities river water get polluted with heavy metals like Cr, Mn, Fe, Co, Ni, Cu, Cd Zn and Ar. The carcinogenic and bioaccumulative nature of the heavy metals causes certain lethal diseases and create hazardous effect on environment. The abundance of these toxic heavy metals found highly near industrialized and urbanized area in Ganga river water in Uttar Pradesh, Bihar and Uttarakhand with order of occurrence Fe > Zn > Cr > Cu > Pb in different season. The present review focus on the toxicity of heavy metals as pollutants, their sources and risk to environment and suggest some strategies for heavy metal pollution management.

Key Words: Environment, Heavy Metal, Pollution, River Ganga, Toxic, Water

I. INTRODUCTION:

Ganga has been a cradle of human civilization since time immemorial. Ganga is the holiest and sacred river in India. Ganga river has great importance and place in Indian civilization that why the National river Ganga is

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important for Community living on the bank of river. Ganga is the largest riverine system of India with well-developed ecosystem and has several important cultural, economic & environmental values. The river spread over 32 km, it travels around 2525 km from Gaumukh to Bay of Bengal [23], [43]. At certain stretches the river water is grossly polluted mostly due to rapid industrialization, municipal sewage discharge, agricultural runoff [60] and negligence of human being the quality of Water is being deteriorated day by day. Water pollution created due to the heavy metal is major environmental as well as socio economic problem [73].

India's 42 Rivers have at least two toxic heavy metals beyond permissible limit (says research conducted by the central water commission) among them Ganga was found to be polluted with 5 heavy metals namely Cr, Cu, Ni, Pb and Fe. These heavy metals can derived from both natural and anthropogenic sources [40]. One of the most crucial property of these heavy metals which differentiate them from toxic pollutants is that, they are not easily biodegradable in Environment [42] [49], they accumulate in human body throughout the food web & causes serious health problems. Higher concentration of heavy metal can form harmful complex compound which critically effect on different biological functions [48]. About 2.5 billion people do not have proper Sanitation as result around 6-8 million people died each year due to water related diseases [68], therefore water quality control is top priority policy agenda in many parts of the world. Clean drinking water is now recognized as a fundamental rights of human being [74]. According to WHO 80% of all diseases in human population are caused by drinking water [14]. As majority of Indians still use water directly from river for their domestic use, for safe guard of human health and environment throughout the investigation of water quality is required which determines suitability of water usage for drinking, industrialization or irrigation purpose [2]. Chemists and researchers all over the world are trying very hard to address the heavy metal pollution problem for sake of a better world and sustainability of life. For that number of scientific procedures and tools have been developed to assess the water contaminants. The procedures include an analysis of physicochemical parameter of water & heavy metals [18]. The aim of this study is to assess the quality of water with respect to heavy metals in Ganga River.

II. SOURCES OF HEAVY METAL

River pollution with heavy metal is becoming a growing global environmental problem in the world. The term "heavy metal" refers to any metal and metalloid element that has relatively high density ranging from 3.5 to 7

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ISSN(Online): 24

g/cm^3.According to WHO common toxic metals are Be , Al, Cr, Mn, Fe, Ni, Cu, Zn, As & Pb .Excess heavy metals in water environment occurs via a wide range of process & pathways by Natural & Anthropogenic sources.

1. *Natural sources* – In nature are found the extreme stages of heavy metal can happen by physical condition are like volcanic eruptions, leach out into the rivers, lakes and ground water due to stroke of water weathering of rocks (igneous rock like granite, basalt & sedimentary rock like limestone, shale, sandstone) [5] .The specific minerals or ores that on dissolution increases level of trace elements that are Haematite, Magnetite [Fe] .Calcite, Cuprite, Malachite [Cu], Chromite [Cr].Arsenic trioxide, Arsenopyrite [As].Calamine, Smithsonite [Zn], Pyrulusite, Rhodochriste [Mn] [6], [9], [10], [26], [70],[72]. Mining activity of the across of world the metal leads to direct and indirect waste into the water [34] Ni ,Pb & Hg get deposited into aquatic system from dry or wet fall out of atmospheric aerosols formed from wind blow dust, forest fire and vegetation [11], [25], [28], [32]
2. *Anthropogenic sources* – The use of metals and their impacts on environment accelerated with major during 19^{th} & 20th [19]

TABLE II

THE SOURCES OF HEAVY METALS

Sr. No	Pollutant	Major sources
1	Arsenic	Arsenic containing fungicides, pesticides and herbicides, metal smelters byproducts of mining activities, chemical wastes.
2	Cadmium	Cadmium producing industries, welding, electroplating.by products from refining of Pb, Zn & Cu, fertilizer industry, pesticide manufacturers, cadmium-nickel batteries, nuclear fission plants.
3	Chromium	Metallurgical and chemical industries, processes using chromate compounds, cement &Asbestos units
4	Copper	Iron and steel industry, fertilizer industry, burning of wood, discharge of mine tailings, disposal of fly ash, disposal of municipal and industrial wastes are the sources of Cu in the atmosphere

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5	Iron	Cast iron, wrought iron, steel, alloys, construction, transportation, machine manufacturing
6	Lead	Automobile emission, lead smelters, burning of coal & oil, lead arsenate pesticides ,smoking, mining, plumbing
7	Mercury	Mining & refining of mercury, organic mercurial used in pesticides, laboratories using mecuries.
8	Nickel	Metallurgical industries using nickel, combustion of fuel containing nickel additives ,burning of coal & oil, electroplating using nickel salts, in cineration of nickel containing substances
9	Zinc	Zinc refineries, galvanizing processes, brass manufacture, metal plating, plumbing

Sources: [44], [38]

III. HEAVY METAL POSITION IN GANGA RIVER:

Ganga River have aesthetic value for millions of people across the world. This river system is used for industrial, agricultural, domestic purpose because of that water quality analysis & monitoring of water with respect to heavy metal is very important.

Many researchers studied on heavy metal pollution of river Ganga. Sharma et al. & Saikia et al. Studied heavy metal contamination of Ganga river water in Mirzapur region and concluded that River was polluted [50],[53]. At Kanpur same study was conducted on heavy metal contamination by researches [20] [58] [61]. Subramanian et al. studied the temporal and spatial variation in the distribution of heavy metal in Ganga [64]. Ajmal et al. Studied heavy metal concentration of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb & Zn and observe variation in elements in water and sediments of river Ganga at various sample station in Uttar Pradesh [3]. Ansari et al observe Ganga river sediment in Kanpur-Unnao which is an industrial area and reported about role of monsoon rain and observed that concentration of Co, Cr, Fe & Ni reduces in monsoon and Cd, Sn, Zn concentration increases in post monsoon period [4]. Singh et al.

Sonpeth Pin-431516 Tal. Sonpeth Dist. Parbhani Karpudkar ACS College

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studied the geogenic distribution of heavy metal in sediments of Ganga River (Cr, Mn, Fe, Ni, Cu, Zn, Cd & Pb) [55]. Khwaja et al. observe the Ganga river pollution near Kanpur because of tannery industries [29]. Chaturvedi and Pandey studied Ganga river water at Vindhyachal Ghat,Varanasi and analyzed physicochemical parameters and few toxic heavy metals and their study proposed that this site was polluted and water is unfit for domestic, irrigation and other purpose. Sinha et al. studied that Mercury pollution presence and found variation in biotic and abiotic components of river water [62]. Kumar et al. studied that Ganga river at Kanpur and Varanasi was shown the impact of effluents discharged through various sources on chemical composition and level of heavy metal. Singh studied toxicity of trace metals (Cu, Cr, Fe, Mn, Zn, Cd, Pb) at Varanasi and observed that Ganga river water is extremely polluted because of industrial effluents [30]. Rai et al. studied Ganga river water quality and heavy metal concentration at different Ghats of Haridwar [46]. Singh et al. studied geochemical environment of the river sediment in middle stretch of Ganga river at Gazipur, Buxar and Balliya which are urban centers and according to them percentage of anthropogenic values of heavy metal concentration in river water showed that Cadmium receives highest value of anthropogenic addition and it is followed by Cr,Cu,Zn & Co like heavy metals [57]. [59]. Singh and Pandey studied middle stream of the Ganga near Varanasi and reported that concentration of heavy metal wear highest in winter and concentration of cadmium exceeded its internationally recommended maximum admissible concentration [56]. Chaudhary et al. studied water pollution and probability of health risk due to imbalanced nutrients river Ganga [12]. Study done by Haritash et al. Concluded that water observed at sample stations of Rishikesh is suitable for drinking purpose with respect to studied physico chemical parameter as well as heavy metals [24]. Arvind Kumar Rai et al. studied water quality parameter of Ganga at Patna in Bihar and observed that water pollution level in river near urban environment increased because of discharge of various types of wastewater & sewage effluent [47].

According to the book 'status of trace and toxic metals in Indian River' published by Central Water Commission under department of water resources department and Ganga rejuvenation ministry of Jal Shakti in 2019. Third edition of this book provide revision of state of trace and toxic metals in rivers. The report comprising the data of 8 elements Ar ,Cd, Cr, Cu, Fe Pb ,Ni & Zn which provide the water quality scenario of Ganga and other river with

Late Rajashri Vitthalrao Patil ACS College Sonpeth Pin-431516 Ta.Sonpeth Dist.Parbhani

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respect to toxic & trace heavy metals. For this observation water is collected from river from different monitoring stations in 3 season-

1. Monsoon- August 2016 &August 2017.

2. Summer- May 2014, April 2016, April 2017 and April 2018.

3. Winter- Nov 2014, Feb 2015, Dec 2015 Dec 2016 and Dec 2017.

The order of higher occurrence of eight metals in different season is different

For nonmonsoon period order is-

Fe>Zn>Cr>Cu>Pb>Ni>As>Cd.

For monsoon period order is-

Fe>Zn>Cr>Cu>Pb>As>Ni>Cd

Seasonal average value of trace and toxic metals at different water stations with acceptable limits as prescribed by Bureau of Indian Standards (BIS: 10500-2012) for Ganga River is given in TABLE II

TABLE II

Sr. no.	Metal	Study period	Water quality site	Metal in µg/l				
				Average			Min.	Max.
				Total	Non monsoon	Monsoon		
1.	Cadmium 3µg/l-3µg/l	April 2017	Utter Pradesh-1.Mirzapur	0.534	0.607	0.209	0.078	3.650
			2.Shahzadpur	0.599	0.719	0.188	0.022	3.936
2.	Chromium 50µg/l-50µg/l	November 2014	Uttar Pradesh 1.Bhitaura	19.149	23.550	1.545	0.470	164.250
			2.Fatehgarh	20.322	24.503	3.600	0.430	175.240
		August 2016	3.Kanpur	23.154	28.589	1.415	0.740	205.820
			4.Kachlabridge	39.233	29.070	79.885	0.380	198.300
3.	Copper 50µg/l-50µg/l	November 2014	Kachlabridge	19.421	23.561	2.860	0.77	107.99
4.	Nickel 20µg/l-20µg/l	November2014	Kachlabridge	5.551	6.240	0.040	0.040	26.840

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ISSN(Online): 2456-0855

5.	Lead 10µg/l - 10µg/l	November 2014	Uttar Pradesh Fatehgarh	3.856	4.650	0.680	0.030	14.610
			Ankitghat	4.200	4.751	2.160	0.220	19.940
		February 2015	Bihar Azmabad	3.253	3.749	1.025	0.020	22.860
			Hathidah	4.464	5.341	0.520	0.040	36.910
		November 2014	Uttar Pradesh Kachlabridge	7.766	9.376	1.325	0.410	33.780
		February 2015	Kanpur	6.607	7.318	3.765	0.050	25.160
6.	Zinc 5mg/l - mg/l	-	-	-	-	-	-	-
7.	Arsenic 10µg/l - 10µg/l	-	-	-	-	-	-	-
8.	Iron 0.3mg/l - 0.3mg/l	March 2014,Nov 2014	Uttar Pradesh Rishikesh	0.134	0.155	0.043	0.002	0.709
		March2014, Nov 2014 Dec 2016	Ankitghat	0.283	0.298	0.224	0.015	1.126
		March2014, Nov2014, Aug 2016, Dec2016, Aug2017 August2017	Kanpur	0.435	0.431	0.448	0.008	1.339
			Allahabad	0.155	0.097	0.416	0.021	0.585
		May2014, Nov2014, Aug2016, Aug2017, Dec2016,Aug 2017	Fatehgarh	0.321	0.283	0.470	0.0130	0.950
			Bihar Azmabad	0.317	0.187	0.899	0.002	1.496
			Patna	0.306	0.170	0.918	0.002	1.371
		Aug2016, Dec2016 Aug 2017	Buxar	0.233	0.117	0.753	0.002	1.029

Late Rajmata Nimbalkar ACS College Sompeth Pin-431515 Ta.Sonpeth Dist.Parbhani

Observed Water quality stations on Ganga river belongs to the states like Uttar Pradesh, Bihar& Uttarakhand. From studid data we get following results for heavy metals concentration in Ganga river water

1. *Cadmium-Cd* is real natural element BIS proposed the maximum desirable limit of this metal is 3µg/l. The highest concentration of Cadmium was observed in April 2017 at Shahazadpur station in Uttar Pradesh the value is 3.936 µg/l.

2. *Chromium-Cr* is used to call metal with two faces as it may be beneficial or toxic. BIS recommended the maximum acceptable limit for Cr is 50 µg/l in drinking water. The quality monitoring at Kanpur in Uttar Pradesh in November 2014 shows highest concentration of chromium is 205.820 µg/l.

3. *Copper-Cu* is common substance. According to BIS acceptable drinking water limit of Cu is 50µg/l. In Uttar Pradesh Kachlabridge water quality station shows 107.99 µg/l concentration level of Copper in November 2014.This water station considered as hotspot for copper pollution.

4. *Nickel-Ni* is naturally essential trace metal. BIS recommended maximum acceptable drinking limit of Ni in water which is used for drinking purpose is 20 µg/l. Kachlabridge water station (Uttar Pradesh) acts as hotspot for Ni pollution with concentration level 26.840 µg/l in Ganga river water.

5. *Lead-Pb* is one of the most common heavy metal. The acceptable drinking Purpose water limit is 20 µg/l which is recommended by BIS. Hathidah in Bihar is hotspots for Lead pollution among all stations with concentration value 36.910 µg/l which is observed in February 2015.

6. *Zinc and Arsenic-* BIS suggested acceptable drinking water concentration limit of As is 10µg/l and for Zn it is 5ml/L. These metals not show any toxicity in river water during study period.

Late Ramesh K... Sonpeth Pin-431516 Ta.Sonpeth Dist.Parbhani

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7. *Ferrous*- Iron shows maximum acceptable drinking water limit is 0.3mg/l. Among all studied water quality stations Azmabad in Bihar shows highest concentration of Iron that is 1.496 mg/l during study period August 2016. December 2016 and Aug 2017.From all the collected data from Ganga river water station kachlabridge (Uttar Pradesh) station is most polluted water station with Cr, Cu, Ni, Pb, Fe metal. Fathegarh, Kanpur, Shahzadpur (Uttar Pradesh) water stations polluted with Cr, Pb, Fe metals. Buxar, Azmabad, Hathidah (Bihar) & Mirzapur. Ankitghat (Uttar Pradesh) these water stations are mostly polluted with Fe and Pb like heavy metals.

IV. EFFECT OF HEAVY METAL TOXICITY:

Heavy metals have harmful effect on human health they create genetic disorder, neurotoxic disorder and Carcinogenecity. IUPAC defined term heavy metal as a "confusing and misleading one".

The most important heavy metals from point of view of water pollution are Zn, As, Cu, Pb, Cd, Hg, Cr & Ni [31].

At low concentration Fe, Cu, Mn, Ni & Zn are required for various life processes but at high concentration they become toxic.

These toxic metals bio accumulate in animal as well as human bodies and to very high toxic amount leading to undesirable effects beyond a certain limit [1],[22] [54]. These metals also disturb synthesis and metabolism of hormones. [52].

V. HEAVY METALS AND HEALTH EFFECTS

1. Arsenic- It causes hyperpigmentation, Organ function disorder [8] increase in stillbirth & spontaneous abortions [15]

2. *Cadmium*-It accumulate with age in kidney, it damage kidney [66] it is carcinogenic with long term exposure, and it can replace calcium in bone [71]. cardiovascular disease [27] bronchial complications [35].

3. Chromium-Toxicological agent & carcinogenic cause dermatitis, ulceration of skin, kidney, liver, circulatory &nerve tissue damage hormonal changes, chronal renal failure, & respiratory complications.

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ISSN(Online): 2456-8805

4. *Copper*-In high concentration causes chronic diseases, nervous system failure, elevated level of Cu causes vomiting, abdominal pain, nausea, diarrhea &anemia [7], [37], causes loss of hair color [13], [33], [67].

5. *Iron*-At high concentration causes accumulation in muscles, liver, affects brain & Central Nervous System [36] anemia [65].

6. *Mercury*-Carcinogenic & causes damage of DNA [51].

7. *Nickel*-Carcinogenic causes systemic toxicity allergy, hair loss, anemia causes renal problems.

8. *Lead*-An enzyme inhibitor [21] & metabolic poison, damage nervous connection, cause blood & brain disorder, hematological damage [39].

9. *Zinc*-It accumulate in muscles & liver, chronic health effects causes cancer, birth defects, damage to the immune system [69], vomiting, dizziness & lack of muscular co-ordination [45], acute renal failure [16]

VI. PLANS TO IMPROVE HEAVY METAL POLLUTION-

Clean drinking water is now recognized as fundamental right of human being. Day by day heavy metal contamination in river increases because of that water quality of Ganga river affected & causes many serious problems on human and environment. For that reason Central and State Government dealing with the matter of reducing pollution in river in India.In 1986 prime Minister of India launched the Ganga action plan (GAP) The aim of this plan was to improve the water quality Ganga of by decreasing pollution. In 2008 government set up National Ganga River Basin Project (NGRBP) which will be first basin level initiative in India to manage an interstate river for water quality and environmental protection [17]. The main objective of this project was to clean up Ganga River. In June 2014 an advanced version of GAP was launched as 'Namami Gange Mission' (NGM) with the aim of integrated river conservation [41]. Because of heavy metal contamination self-purify nature of the river get affected which causes growth of high level pathogenic bacteria.To enhance the Water Quality of Ganga river by sustainable way the systematic monitoring, strict law implementation & people awareness must be required.

VII. CONCLUSIONS-

This review article suggests that Ganga river water is highly polluted with Cr, Cu, Ni, Pb & Fe like toxic metals which come from anthropogenic activities, industrial, municipal and sewage discharge. Present study shed

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light on heavy metal contamination level in Ganga river which is significantly changes during different season and their ranges found above the permissible limits of BIS (10500-2012) for drinking and domestic use. In Uttar Pradesh. Bihar and Uttarakhand Ganga river water is unsafe for drinking. Heavy metals are Carcinogenic and Bio accumulative in nature because of that reason contamination of Ganga water by heavy metals should be closely monitored. The present study also recommended that awareness should be spread among the people regarding hazardous consequences of consumption of polluted water.

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