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A Study of Heavy Metal Pollution of Ghaggar River

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ABSTRACT: The present study briefly deals with the presence of trace heavy metals in the waters of River Ghaggar throughout its stretch. The study was carried out in October 2016 (post monsoon) on 16 selected sampling stations of River Ghaggar.Concentrations of heavy metals viz., Fe, Hg, As, Pb, Cu, Zn, Cd, Ni, and Cr were studied throughout the 466 km stretch of river Ghaggar, though total 16 sites were selected but sampling is not possible due to dry bed of river in lower 4 sites. In the selected research area, the Ghaggar River is receiving the domestic, industrial and municipal wastewaters/effluents all along its course. All in all, the dominancy of the analyzed heavy metals in the surface water of Ghaggar followed the sequence: Fe> Zn > Ni > Cu > Cd > Cr >Pb > Hg >As. Arsenic was absent in all the samples.

I. INTRODUCTION

Water pollution may be defined as the "alternation of physical and biological properties of water or any addition of foreign material and the natural water which may have harmful effect on living beings, human agricultural system and other biological aspects, either directly or indirectly or immediately or after sometimes or after a very long period" [17]. Rivers are natural steam of water emptying into an ocean, sea, or other bodies of water and usually fed along its course by joining tributaries. Rivers are very important carriers of water and nutrients to regions all around the earth [24]. In the present study, the Ghaggar River was selected to evaluate the heavy metal characteristics of its surface water in upper reaches. The Ghaggar River originates from the Siwalik Hills of Himachal Pradesh and Haryana. It runs along the foot of the Siwaliks and flows through Haryana and Punjab to Rajasthan and then disappear itself in the sands of the Thar Desert. The selected study area falls within the boundaries of several states and covering parts of different districts of Haryana and Punjab and Rajasthan. At downstream sites various point sources *viz.,* Medkhali Nallah, Sukhna Choe, Jharmal Choe, Dhabi Nallah, Dhakansu Nallah, Patiala Nadi, Markanda River, and Shaabaad Nallah are joining the Ghaggar River and discharging their untreated effluents into it.

Generally, heavy metals are present in trace amounts in water. Some of the heavy metals or trace elements are essential for physiological functions of living tissue and regulate many biochemical processes. The deficiency of heavy metals is harmful. The deficiencies of heavy metals in human beings and animals have been identified [7]. The same metals, however, at increased level may have severe toxicological effects on human beings [5]. During the last decade some studies have been conducted to evaluate the physico-chemical status of the Ghaggar River [3, 11, 12, 15]. Therefore, monitoring these heavy metals is important for safety assessment of the aquatic environment and human health in particular.

II MATERIAL AND METHODS

A. Sample Collection

After determining the location of the sampling points, 12 samples of water was collected. For heavy metal analysis the primary sampling point was in the surface water layer (0-5 cm from the surface) at main flow. Surface water was collected using acid-leached polythene bottles and chilled immediately to 3° to 4°C.

B. Preliminary treatment and analysis of samples for heavy metal determination

Preliminary treatments of samples were done by following international standard method given by APHA [2]. Water Sample was agitated to obtain homogeneous suspension of solids. 500 ml sample was measured and transferred to an evaporating dish; sample was acidified with 5 ml HNO_3 and evaporated on a steam bath to 15 to 20 ml. Then the solution was transferred, together with any solids remaining in the dish, to a 125 ml conical flask. 5 ml additional HNO_3, 10ml H_2SO_4 and few glass beads (to prevent bumping) were added into the solution and it was evaporated on a hot plate until dense fumes of SO_3 appear in the flask. A clear solution was observed and all the HNO_3 was removed. The solution was cooled to room temperature, carefully diluted to about 50 ml and filtered through a porcelain filter crucible & washed the residue with 2 small portion of water. Then the filtrate was transferred to a 100 ml volumetric flask and made up to the mark with distilled water. An aliquots of this solution were taken for the determination of metals.

The samples were analyzed by an atomic absorption spectrophotometer (Type:) using an air acetylene flame. All the spectroscopic measurements of the standard metal solutions as well as the sample solutions were done at their respective wavelength of maximum absorptions λmax.

III RESULTS AND DISCUSSION

Table 1 is showing distributional pattern of trace elements in Ghaggar River water at different monitoring sites and impact of point sources wastewaters/effluents on the river.

Cadmium is an element that occurs naturally in the earth's crust. It is uniformly distributed in the Earth's crust, where it is generally estimated to be present at an average concentration of between 0.10 and 0.50 µg/g. Cadmium is produced during extraction of zinc and is used in plating industry, pigments, in manufacture of plastic material, batteries and alloys. The water is contaminated with cadmium by industrial discharge, leaches from land filled area. Cadmium is released to environment in wastewater, and disperse pollution is caused by contamination from fertilizers [25]. Cadmium precipitates from solution at high pH and toxicity of it depends on pH and hardness of water [18]. Cadmium is biologically non-essential and non-beneficial constituent. In the river water, only two sites observe the concentration of cadmium. Ottu has concentration of 0.016 ppm and at Tepla to a maximum of 0.045 ppm at. Concentration of Cd exceeded the Desirable limit of 0.003 ppm at both sites. The possible sources of cadmium in river water system are contributed by domestic wastewater released from residential area, impetuously use of pesticides, fertilizers used in palm oil estates along the rivers bank and local air pollution caused by open burning [21]. Cadmium ranks next to mercury in its toxicity. Exposure at low levels usually does not produce immediate health effects, but may cause severe health problems over long periods. The gastrointestinal tract is the major route of Cd uptake in both humans and animals. Cadmium is toxic to humans, animals, micro-organisms and plants, however only a small amount of cadmium intake is absorbed by the body and will be stored mainly in bones, liver and, in case of chronic exposure, in kidneys. In the last few years there have been some evidences that relatively low cadmium exposure may give rise to skeletal damage due to low bone mineral density (osteoporosis) and fractures. The toxicity of the metal lies in that, after absorption, it accumulates in soft tissues. Animal tests have shown that cadmium may be a risk factor for cardiovascular disease [10].

Table 1: Results of Heavy Metals Analysis of Ghaggar River System Surface Water (Oct. 2016).

Site	Location	Cadmium (as Cd)	Zinc (Zn)	Iron (Fe)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Nickel (Ni)	Chromium (Cr)	Arsenic (As)
1	Amravati Enclave	0	0	0.11	0	0.018	0	0	0	0
2	Sec. 25 Panchkula	0	0.021	0.243	0.022	0	0	0.01	0	0
3	Mubarkpur	0	0	0.9	0.021	0	0.018	0.03	0.012	0
4	Bhagwanpur	0	0	1.2	0.021	0	0.016	0.04	0.046	0
5	Tepla	0.045	1.89	2.2	0	0.012	0	0	0.023	0
6	Ratnedi	0	0	0.31	0	0	0.012	0.01	0	0
7	Khanori	0	0	0.24	0	0	0	0	0	0
8	Jakhal	0	0	0.2	0	0	0	0	0	0
9	Ratia	0	0	0.2	0	0	0	0	0	0
10	Sardulgarh	0	0.023	0.31	0	0.045	0	0	0	0
11	Sirsa	0	0	N.D.	0	0	0	0.015	0	0
12	Ottu	0.021	0.014	N.D.	0.012	0	0	0.0112	0	0
BIS (IS: 10500, 1991)	Desirable	0.003	5	0.3	0.05	0.01	0.001	0.02	0.05	0.01
	Max Permissible	N. R.	15	N.R.	1.5	N. R.	N. R.	N.R.	N.R.	0.05

Zinc is very essential micro-nutrient in human body but at very high concentration it may cause some poisonous effects [14]. Copper and cadmium augment the toxicity of Zn while increase in hardness decreases the toxicity. At only four sites Zinc concentration observed in river surface water ranged from a minimum of 0.014 ppm at Ottu to a maximum of 1.89 ppm at Tepla. Zinc toxicity also increases with increase in temperature and decrease of dissolved oxygen. Zinc is highly and chronically toxic to aquatic organisms particularly to fish when the hardness of water is less and temperature is high [19]. Zinc contents in the Ghaggar remained well within the desirable limit of drinking.

Iron is an essential constituent of human nutrition. Concentration of Fe varied from 0.11 to 2.2 ppm in the selected stretch of the river. The river water quality at Tepla, Mubarkpur and Ratnedi sites has been affected by various point sources *i.e.* Dhabi Nallah, Jharmal Choe and Patiala river effluents. At Tepla site high concentration of Fe was observed almost of the double of the previous site concentration due to non-point pollutants mixing. Downstream to Tepla site concentration of Fe was slowly decreased up to the Ratia and then there is slightly increase in concentration due to non point source. Iron contents exceeded the desirable limit of BIS at four sites namely Bhagwanpur, Tepla, Ratnedi and High concentration of Fe in the water imparts a bitter taste and stains the clothes, if used. High concentrations of iron generally cause inky flavour, bitter and astringent taste [9]. It can also discolour clothes, plumbing fixtures and cause scaling which encrusts pipes. The red-rod disease of water caused by bacterial precipitation of hydrated oxides of ferric iron with consequent unaesthetic appearance to water, clogging of pipes, pitting of pipes and occurrence of foul smells, is due to the presence of relatively high iron in sediment and water [8].

Copper is an essential trace element for human body. Copper contents ranged from a minimum of 0.012ppm at Ottu to a maximum of 0.022ppm at Panchkula. 100% of the analyzed sampling sites, the Cu concentrations were found below the detectable limit. Copper is also extensively used in agriculture in the form of fertilizers, fungicides and pesticides. It has also been established that Cu deficiency is associated with anaemia, diarrhoea and demineralization of the bone of the new born baby. Copper concentrations in treated water normally increase during supply, particularly in systems with an acid pH or high-carbonate water with an alkaline pH the primary import pathway of copper to soil or waste disposal fertilizer application and atmospheric deposition [4].

Lead is the most common of the heavy elements. Several stable isotopes exist in nature, 208Pb being the most abundant. Lead is used principally in the production of lead-acid batteries, solder and alloys. Lead (Pb) is a soft metal such that has been known many applications of it over the years. During present investigation, lead concentration varied from 0.012 ppm at Tepla to 0.045 ppm at Sardulgarh. Only three sites showed the trace amount of Pb. Lead concentration was found above the desirable limit of BIS. It is not known to be essential for the functioning of biological systems and the exposure to this metal should be kept as low as possible. *Lead.* Lead (Pb) exposure in children and adults can cause a wide spectrum of health problems, ranging from small effects on metabolism and intelligence to convulsions, coma, renal failure, and death [20].

Mercury (Hg) is the only common metal that is liquid at room temperature. Mercury occurs naturally in the earth's crust. Although it may be found in air, water and soil, mercury is mostly present in the atmosphere as a gaseous element

Mercury concentration ranged from 0.012-0.018 ppm. In Khanori to Ottu stretch, Hg contents were not detectable. River water at Bhagwanpur, Mubarkpur and Ratnedi sites even crossed the maximum permissible limit and hence river water was not suitable for drinking. It may pose serious health hazards, if used for drinking. After entering into the aquatic ecosystem, the inorganic mercury is changed into methyl mercury through microbial activity that is the most toxic and most bio-available type of mercury for living organisms [13]. High level of mercury can cause harmful effects, such as nerve, brain and kidney damage, lung irritation, eye irritation, skin rashes, vomiting and diarrhoea. Exposure to mercury may mainly occur as a consequence of the deposition from air into water or into soil. By natural biological processes certain microorganisms can change mercury into methyl mercury, a highly toxic and stable form that builds up in fish, shellfish and animals that eat fish, accumulating in the food chain. General population is exposed to methyl mercury through the food chain; fish and shellfish are the main source of exposure through the ingestion pathway [6].

Nickel is the 24th most abundant element (twice as Cu) and comprises approximately 0.008% of the content of the earth's crust; hence, it is a natural component of soil (parent material) and water [1]. It is the 5th most abundant element in the biosphere, Ni was only discovered through the mining of other metals. Its principal ores are nickelite (NiAs), millerite (NiS), and pentlandite ([Ni, Fe]S). Nickel is released into the environment from a variety of natural and anthropogenic sources. Among industrial sources, a considerable amount of environmental Ni derives from the combustion of coal, oil, and other fossil fuels.

Other industrial sources that contribute to nickel emissions are mining and refining processes, nickel alloy manufacturing (steel), electroplating, and incineration of municipal wastes [22]. Wastewater from municipal sewage treatment plants also contributes to environmental metal accumulation [23]. Among 12 sampling sites only 6 sites shows the presence of Ni, among these Bhagwanpur and Mubarkpur sites have higher concentration of Ni (0.04 ppm and 0.03 ppm) than the desirable limits. Rest four sites namely Panchkula, Ratnedi, Sirsa and Ottu have concentration of Ni within the limit. In small quantities nickel is essential, but when the uptake is too high it can be a danger to human health. Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. The immediate symptoms included headaches, nausea, weakness, dizziness, vomiting, and epigastria pain. There was a latency period of 1 to 5 days, followed by secondary symptoms, which included chest constriction, chills and sweating, shortness of breath, coughing, muscle pains, fatigue, gastrointestinal discomfort, and, in severe cases, convulsions and delirium [6].

At only three sites Chromium concentration observed in river surface water ranged from a minimum of 0.012 ppm at Mubarkpur to a maximum of 0.046 ppm at Bhagwanpur. Chromium contents in the Ghaggar remained well within the desirable limit of drinking. The health hazards associated with exposure to chromium are dependent on its oxidation state. The metal form (chromium as it exists in this product) is of low toxicity. The hexavalent form is toxic. Adverse effects of the hexavalent form on the skin may include ulcerations, dermatitis, and allergic skin reactions. Inhalation of hexavalent chromium compounds can result in ulceration and perforation of the mucous membranes of the nasal septum, irritation of the pharynx and larynx, asthmatic bronchitis, bronchospasms and edema. Respiratory symptoms may include coughing and wheezing, shortness of breath, and nasal itch. Hexavalent chromium is toxic to plants and animals. It causes yellowing of leaves of wheat and paddy [6].

Arsenic is ubiquitous and ranks 20th in natural abundance, comprising about 0.00005% of the earth's crust, 14th in the seawater, and 12th in the human body [16]. Arsenic occurs in the environment in rocks, soil, water, air, and in biota. At all the Sampling Sites arsenic was absent.

IV. CONCLUSION

The concentration of above heavy metals in the river water exhibiting the following order: Fe> Zn > Ni > Cu > Cd > Cr >Pb > Hg >As. In the present study the concentration of trace elements like Cd, Fe, Ni and Hg far exceeded the maximum permissible limits of drinking at many sites. The study revealed that the Ghaggar River water contained very high concentration of Cd, Fe, Ni and Hg and crossed the desirable as well as maximum permissible limit of BIS. River water at Tepla, Bhagwanpur sites even crossed the maximum permissible limit prescribed for iron concentration and water was not suitable for drinking. The observed high concentration of heavy metals particularly in downstream stations indicating substantial inputs coming from industrial, agricultural and municipal effluents through point and non-point sources all along the river route. In terms of As, Cr and Zn concentration river water was least contaminated. Kundu [15] detect the heavy metals in upper regions of Ghaggar. The occurrence of heavy metals in the river Ghaggar water more than that of recommended maximum permissible limit all along its route in Haryana was reported by Kaushik *et al.* [12]. They were also found that industrial, municipal and agricultural wastes from Punjab region were main sources of heavy metals pollution in the river water at downstream stations.

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