Evaluation of River Jehlum Water for Heavey Metals (Zn, Cu, Fe, Mn, Ni, Cd, Pb, and Cr) and it's Suitability for Irrigation and Drinking Purposes at District Muzaffarabad (A.K)

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Summary: The present research was conducted to evaluate the suitability of Jehlum River water quality for irrigation and drinking purposes at district Muzaffarabad with respect to the levels of heavy metals Zn, Cu, Fe, Mn, Ni, Cd, Pb and Cr during high and low flow. Thirty water samples were collected from selected locations in the study area at each high and low flow conditions. Large variations were found in almost all heavy metals under study with most of lower values being observed during high flow conditions. The concentration of Zn, Cu, Fe, Mn, Ni, Cd, Pb and Cr varied from 0.005-0.084, 1.21-2.24, 0.005-0.57, 0.002-0.158, 0.1 to 7.01, 0.004 to 0.091, 0.004 to 0.83 and 0.02 to 0.7 mg L^{-1} respectively at high flow. At low flow, the concentration of Zn, Cu, Fe, Mn, Ni, Cd, Pb, and Cr ranged from 0.005 to 0.111, 1.02 to 1.44, 0.15 to 4.24, 0.035 to 0.883, 0.18 to 5.16, 0.003 to 0.78, 0.03 to 2.34 and 0.04 to 0.47 mg L^{-1} respectively. The statistical analysis of the samples showed that all the heavy metals were significantly different when collected from different locations and time with exception of Fe, which remains fairly constant throughout the sampling site at high flow but significantly different at low flow. Heavy metals including Ni, Cd, Cr, Pb, were a serious problem as there mean value at both conditions exceeded from the WHO drinking water standards. For irrigation purposes, Cd and Pb were within permissible levels according to USEPA. Heavy metals such as Zn, and Mn during high and low flow were within the limits of WHO and USEPA standards for both drinking and irrigation purposes while Fe at low flow is posing threat to human consumption but for irrigation, its concentration both at high and low flow was within the permissible limits. The Cu concentration was higher than permissible level for irrigation at high flow.

Introduction

Quality of water depends upon certain physical, chemical and biological characteristics [1]. Plants and animals require water that is moderately pure and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms. Severe water pollution can kill large numbers of fish, birds, and other animals. People who ingest polluted water can become ill, and, with prolonged exposure, may develop cancers or bear children with birth defects.

Heavy metals get into water from many sources, including industries, automobile exhaust, mines, wastes, and even natural soil [2]. Like pesticides, heavy metals become more concentrated as animals feed on plants and are consumed in turn by other animal. When they reach high levels in the body, heavy metals can be immediately poisonous, or can result in long-term health problems similar to those caused by pesticides and herbicides [3]. Major types of pollutants introduced by the wastewater are nutrients, synthetic chemicals and pathogenic microbes [4]. In Pakistan, only limited population has access to public water supply, not necessarily clean while the rest of population is dependent upon direct withdrawal of water from both surface and ground sources, where available for its daily needs. Most of the quality problems in Pakistan are due to lack of waste disposal regulation; non availability of treatment facilities and due to lack of public awareness about water quality.

The River Jehlum whose source lies in occupied Kashmir meets with the River Neelum at Domail in the city of Muzaffarabad. Its total length is about 620 km [5]. The source of Jehlum River is the spring VeriNag, situated at an altitude of 6600 m. The cities of Islamabad, Ovantipura, Srinagar, Sanpur, Baramulla, Muzzaffarabad and Kohala are situated on the bank of the river which diverting its effluent to the river. The water of Jehlum River is used for hydroelectricity, irrigation and drinking purposes down stream. Since no research is done in the past to evaluate its suitability for irrigation, drinking and fisheries, the present study aimed to analyze the water and assess the impact of effluent discharge to the river and its impact on down stream user.

Results and Discussion

Analysis of thirty water samples from different location of Jehlum River at high and low flow for heavy metals (Zn, Cu, Fe, Mn, Cr, Cd, Ni and Pb) were performed to evaluate the suitability of water for irrigation and drinking purposes. The results are shown graphically and compared with WHO [6] standards for drinking and USEPA [7] standards for irrigation.

Zinc is an essential element for plant food and exist in water and soil as an organic complexes and inorganic salts. Zinc is required for growth, sexual development, wound healing, infection fighting, sense of taste and night vision in human [6]. Fig. 1 shows the concentration of Zn in water samples. It ranged from 0.005 to 0.084 mg L^{-1} with a mean value of 0.028 mg L^{-1} during high flow. During low flow, Zn values ranges from 0.005 at Rasheedabad and 0.111 mg L^{-1} at Kohala with the mean value of 0.045 mg L^{1}. The Zn standard for drinking [6] water is 5 mg L^{-1} while the safe limit for Zn concentration in irrigation water ranges from 2 to 5 mg L^{-1} [7]. It reveals that the Zn concentration both at high and low flow was much lowers than the above-mentioned standards, thus water of Jehlum River posing no threat of Zn as pollutant for drinking and irrigation purposes. By comparing the Zn conc. at high and low flow; it is clear that higher values were recorded at low flow than high flow that may be due to dilution effect during high flow where the snow melting and rainfall event are high during this period. However, there were few exceptions (sample No. 13, 24 and 25) where Zn concentration was high at high flow compared to low flow. This may be due to the discharge of effluent enriched with Zn as the samples were collected from the river bank at point of no turbulence, thus the effluent might have not mixed well with river water at the time of sampling. These findings are similar to the findings of Zakirullah *et al* [8] who reported higher level of Zn during low flow in river Kabul.

The Cu levels are shown in Fig 2. From the figure it can be seen that unlike Zn, higher values were recorded during high flow and lower values were noted at low flow conditions. At high flow, the highest concentration of Cu was noted in sample 3 (Hattian Balla) i.e. 2.236 mg L^{-1} and lowest concentration was noted at sample 2 (Naili) which was 1.209 mg L^{-1} whereas at low flow, the highest value of Cu concentration was found at Naili (1.442 mg L^{-1}) and lowest (1.017 mg L^{-1}) at CMH Muzaffarabad. There was only one exception in sample No.2 where Cu concentration at high flow was much lower than the values observed at low flow. This low concentration of Cu may be associated with formation of stable insoluble organic complexes in the river discharge at this point [9, 10]. The provisional health guideline for Cu concentration in drinking water is 2 mg L^{-1} [6]. The Cu concentration

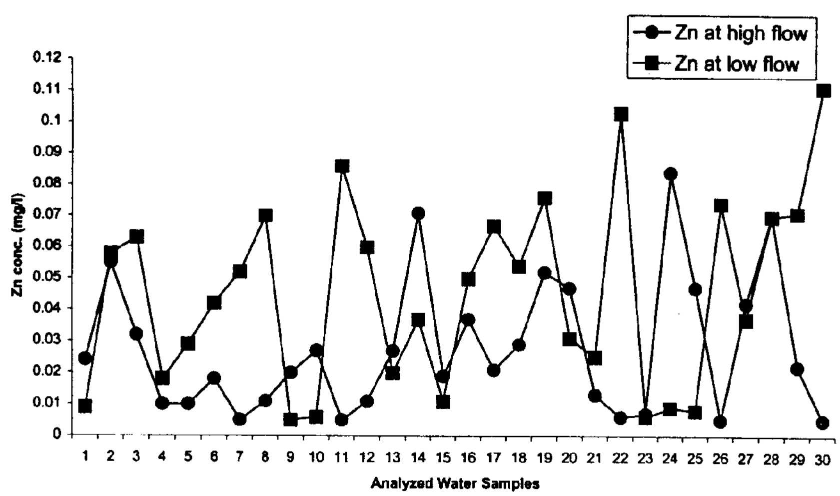

Fig. 1: Zn conc. at high flow and low flow of Jehlum River.

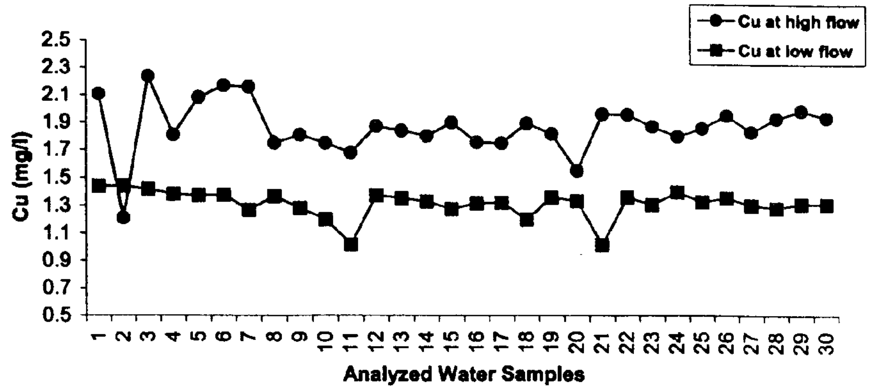

Fig. 2: Cu conc. at high flow and low flow of Jehlum River.

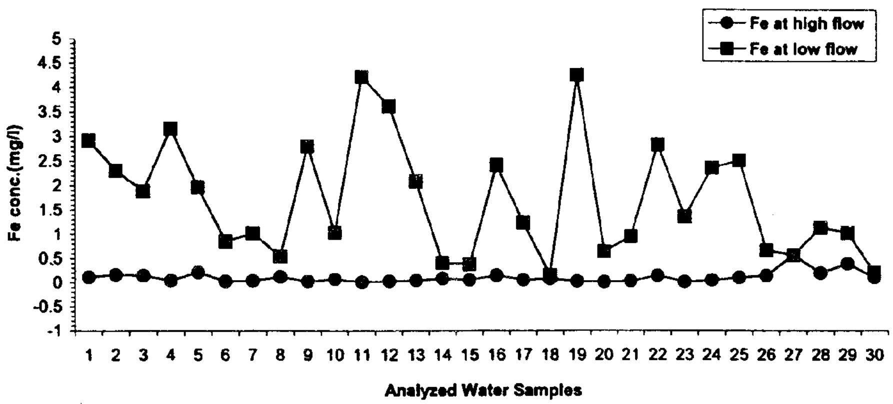

Fig. 3: Fe conc. at high flow and low flow of Jehlum River.

in water samples for drinking purpose is higher during high flow at different location including Chinari, Hattianballa, Ghari Dopata, Majhoi, and Langurpura. The numerical standards of Cu conc. for irrigation water is 0.2 mg L^{-1} [7]. It is obvious from the results that the Cu level in river water at high flow was much higher than safe limits and may cause serious health hazards for human and animal consuming such water. The reason of elevated levels at high flow may be more suspended solid rich in Cu minerals. Khan *et al* [11] noted elevated levels of Cu at Hudaira drain and reported that water of Hudaira drains are not suitable for irrigation due to higher levels of heavy metals in it.

Iron is one of the most abundant metal in the earth crust and is essential for plants, animals and human being. The results of Fe are shown in Fig. 3. The concentration of Fe at high flow varied very little throughout the sampling locations and was well within the permissible limits [6]. At high flow, the concentration of Fe was little high in sample 27 (Kulian) indicating effluent inflow rich with Fe material or sediments rich with Fe mineral while rest of the sample showed fairly constant pattern. At low flow, it ranged from 0.15 to 4.24 mg L^{-1}, being lowest in sample 18 (Challa) and maximum at Upper Plate. According to the WHO standards, the Fe concentration at low flow was significantly higher than permissible limits for drinking. The standard of Fe concentration for irrigation is 200 mg L^{-1} [7]. According to these limits, the water of Jehlum River has no limitation for irrigation at both high and low flow but may cause health problem if utilized directly by human and livestock during low flow [12]. By comparing the results of samples collected from different locations and time, it is clear from Fig. 3 that there were slight changes in Fe conc. at high flow, while at low flow there were significant variation which might be due to effluent discharge carrying material rich in Fe [13, 14].

The Mn, one of the least toxic elements [6] is essential for both plants and animals. The concentration of Mn in water samples (Fig. 4) during high flow ranged from 0.002 to 0.158 mg L^{-1} while at low flow it varied from 0.035 to 0.882 mg L^{-1}. The Mn concentration of 0.75 mg L^{-1} in the drinking water supply had no apparent adverse effect on consumers [13]. For irrigation, the Mn concentration should not exceed 2 mg L^{-1} [7]. It reflects that Jehlum River water is suitable for both drinking and irrigation purposes with respect to Mn levels. Similar results were noted by study conducted by IUCN [3] for Kabul River.

The results of Ni in water samples collected during high and low flow are shown in Fig. 5. At high flow, its concentration varied from 0.1 to 7.01 mg L^{-1} being lowest in sample 1 (at Chinari) and maximum in sample 27 (at kullian). At low flow, its concentrations varied from 0.18 to 5.16 mg L^{-1}. According to WHO [6] standard for drinking and USEPA [7] standard for irrigation, the permissible limit of Ni is 0.02 mg L^{-1}. This shows that the Ni conc. of River Jehlum is appreciably high and may cause problem for health of human and livestock as well as standing crops. By comparing the results of high and low flow as shown in Fig. 5, it indicate that there was no regular pattern of Ni conc. and it fluctuated widely which indicate that after effluent discharge, it soon diluted and the values were lowered but the point of effluent discharged showed

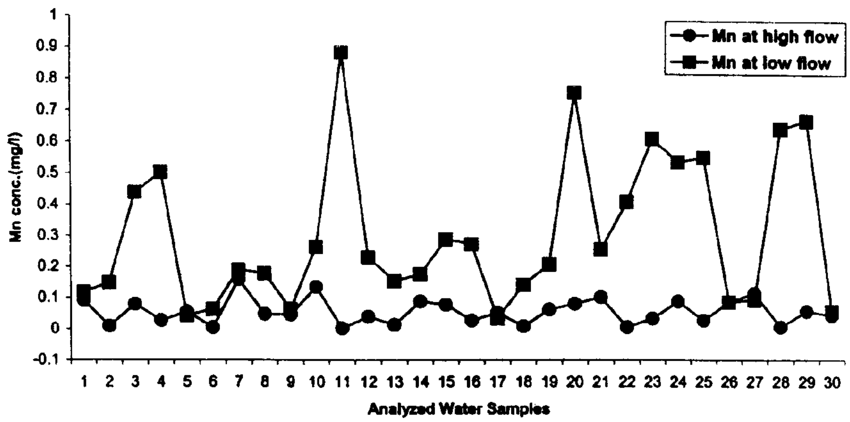

Fig. 4: Mn conc. at high flow and low flow of Jehlum River.

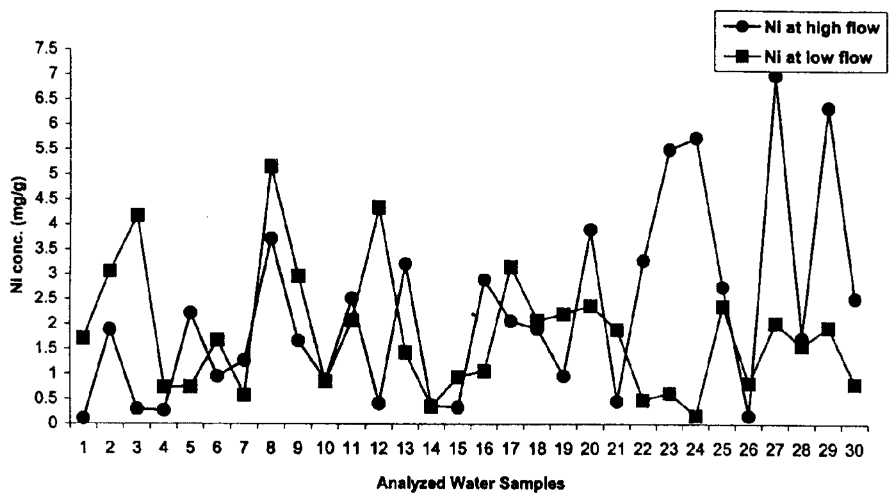

Fig. 5: Ni conc. at high flow and low flow of Jehlum River.

high Ni concentration [13]. The higher concentration of Ni observed in samples 21-30 during high flow were colleced from points being influenced by anthropogenic activites such as domestic wastes and vehicular emission from the surrounding areas close to Muzaffarabad city.

The results of Cd in river Jehlum water are shown in Fig. 6. A guideline value for Cd in drinking water is 0.003 mg L^{-1} [6]. During high flow it ranged from 0.003 to 0.091 mg L^{-1}. Similarly, during low flow, the water samples collected from Chinari having the highest value of Cd (0.78 mg L^{-1}) and the lowest was at Mianibandi (0.003 mg L^{-1}) The irrigation standard recommended by USEPA for Cd concentration in water is 5 mg L^{-1}. According to these standards, the Jehlum River water is rich in Cd concentration required for drinking while it may be used for irrigation without any harmful effect. Bakraji and Karajo [14] reported that Cd gets into a ground water from corrosion of galvanized pipes and fittings and to the surface water from the effluents discharged from the pipe industries. Jehlum River has very little variations in Cd conc. during high and low flow.

Fig. 7 shows the Pb concentration during high and low flow conditions of river. During high flow, it

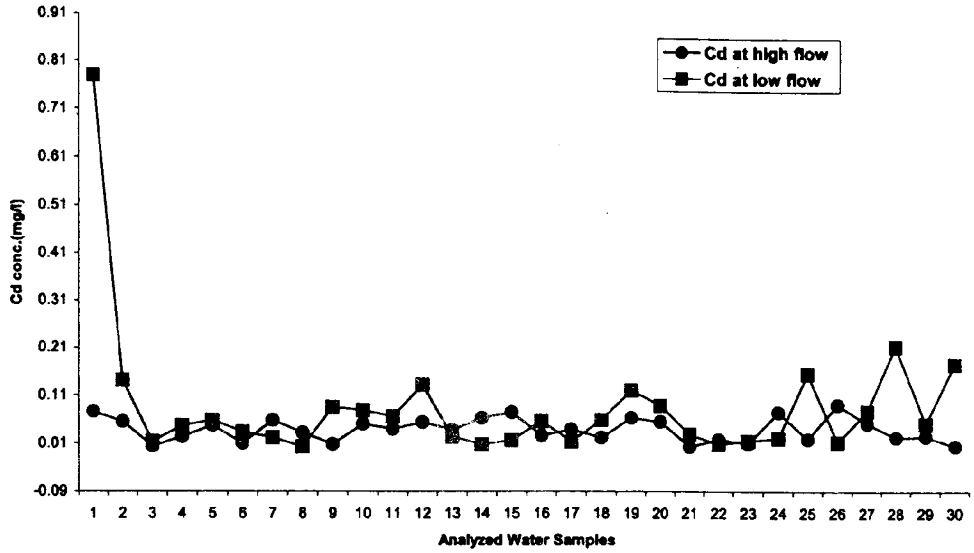

Fig. 6: Cd conc. at high flow and low flow of Jehlum River.

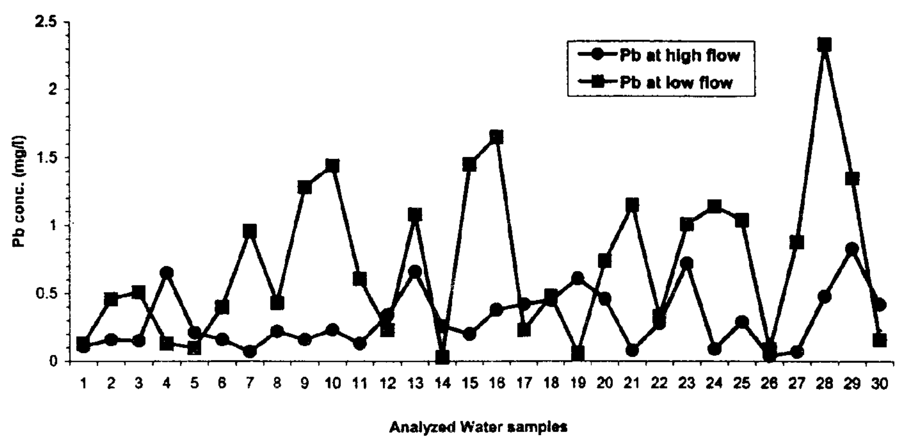

Fig. 7: Pb conc. at high flow and low flow of Jehlum River.

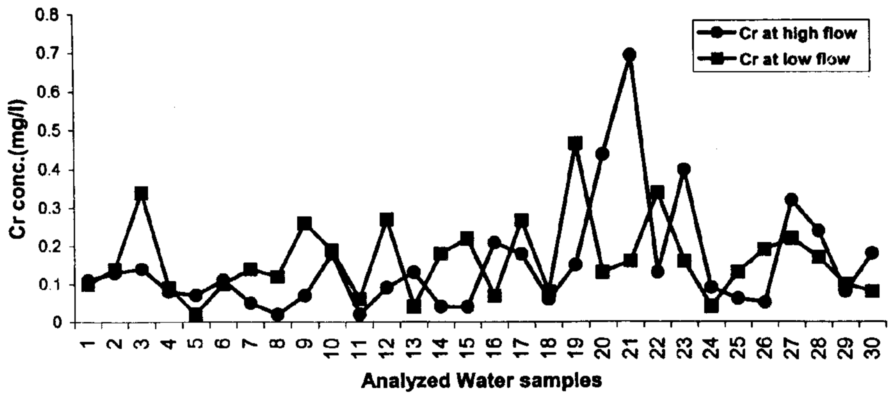

Fig. 8: Cr conc. at high flow and low flow of Jehlum River.

attains its maximum concentration at Barsala (0.83 mg L^{-1}) and minimum (0.04 mg L^{-1}) at Dulai while during low flow, its concentration ranged from 1.01 to 2.34 mg L^{-1}. The permissible limits of WHO and USEPA for drinking and irrigation purpose is 0.01 and 5 mg L^{-1} respectively. The results of the present study for Pb concentration reveals that Jehlum River water is not suitable for drinking while it may be used for irrigation without any reservation both during high and low flow.

Fig 8 shows the results of Cr concentration during high and low flow condition from different locations. The Cr concentration standard in drinking water is 0.05 mg L^{-1} [6]. During high flow, the highest concentration of Cr (0.44 mg L^{-1}) was found at Lowerplate and the lowest (0.02 mg L^{-1}) at Mianibandi. Similarly, the concentration of Cr was highest at Gharidopatta during low flow. The recommended standard of Cr concentration for irrigation water is 0.1 mg L^{-1} [7]. The Cr conc. was higher than permissible value in majority of site showing it unsuitability for both drinking and irrigation purposes. The elevated levels of Cr in sample 20 and 21 may be due to effluent discharged enriched with Cr at the source. It was further noted that samples collected from down stream (20 to 30) were located closer to Muzafferabad city which resulted unusual peaks for certain elements like Zn, Ni, Pb (at low flow) and Cr. However, such pattern, are not uncommon in perennial flow such as river Jehlum. Zakirullah *et al* [8] reported higher concentration of Cr in river Kabul.

Experimental

The objective of the present study was to evaluate the Jehlum River water quality for irrigation and drinking purpose. Thirty water samples were collected from selected locations in the study area of the Jehlum and Neelum River (distt: Muzaffarabad). The selection of these locations was made on the basis of the catchment's areas while keeping in view the population density, live stock and human activities at or near the riverbank in consideration. The main reason of the selection of these points was because the above-mentioned factors are major sources of pollution.

The samples were collected at high and low flow. High flow refers to the months of July and August when the water flow in river rises due to ice melting from surrounding mountains and monsoon rains while low flow refers to the month of December and January when the flow of water is minimum.

Clean plastic bottles of half liter size were used for sample collection. The grab method [11] was used for water sample collection. The samples were taken from each point receiving city/village effluents followed by a sample about one kilometer down stream from the point of effluent discharge. The bottles were rinsed twice with water. The filled bottles were stoppered, labeled and transported to the laboratory of Soil and Environmental Sciences Department of NWFP, Agricultural University, Peshawar. The results have been reported comparing with the results of WHO (World Health Organization) [6] and USEPA (United State Deptt. of Environment Protection Agency) [7] standards.

Analytical Measurement

The samples were collected in duplicate and the results were averaged. Water samples were kept in $4C^0$ before analysis and were analysed within two weeks. The samples were filtered through Millipore 0.45 μm filter. Heavy metals in the filtrate were determined with the help of atomic absorption spectrophotometer (Parkin Elmer Model 85).

A stock (1 L) standard solutions of all the elements of interest were prepared and from the stock solution, a series of diluted solutions were made. The accuracy of the instrument (AAS) was checked after each 10 samples by feeding standard solution of the respective element as a reference sample. Samples that were over caliberated were further diluted 25 times.

Conclusions

1. Heavy metals including Ni, Cd, Cr, Pb, were a serious problem at both high and low flow conditions, which exceeded from the WHO drinking water standards while those crops which are directly utilized (without cooking) should be avoided at certain points particularly at site which directly receiving effluents.

2. Heavy metals such as Zn, and Mn, during high flow and low flow were within the limits of WHO and USEPA standards for both drinking and irrigation purposes, however, Fe at low flow and Cu at high flow is posing threat to human consumption but for irrigation, its concentration both at high flow and low flow is within permissible limits.

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