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Investigation of Heavy Metals Concentration in Community Wastewater of Hamedan city and its Effects on the Environment

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ABSTRACT

Heavy metals are one of the most important sources which threaten living organisms. The main objective of this study is to determine the quantity of dissolved Cadmium (Cd), Copper (Cu), Zinc (Zn) and Lead (Pb) concentrations in municipal wastewater of Hamedan city. Simple random sampling was the method chosen for this study. Sampling station was located at the end point of wastewater collection system or nearest manhole to municipal wastewater treatment plant of Hamedan. All samples were kept in100 mL polypropylene bottles and stored at 4o C until analyses. All analyses were performed according to the procedures outlined in standard methods. Samples were digested in laboratory and then, dissolved Cd, Cu, Zn and Pb concentrations of the wastewater samples were analyzed by Inductively Coupled Plasma (ICP). SPSS software (version 18) was used in this study for the statistical analysis. The average concentration of each parameter was estimated and compared to standard. The obtained results showed that, the average concentration of Cd, Pb, Cu and Zn of the samples was 60.98, 44.27, 96.86 and 176.40 PPb, respectively. Statistical studies and regression analyses revealed that there is a significant relationship between Cd and Cu concentrations. The results of total contents of the studied heavy metals (Cd, Cu, Pb and Zn) in Hamedan community wastewater indicated that the average amount of Cu, Pb and Zn did not exceed the Iran maximum permissible limits. But, the concentration of Cd in mentioned wastewater was out of acceptable range of Iran maximum permissible limits. Heavy meals are considered as the most important pollutants in the environment due to their persistence, toxicity and bioaccumulation problems. Hamedan wastewater is collected and then transported to wastewater treatment plant and its treatment system is complete mix activated sludge process. Heavy metals can accumulate in biological systems in wastewater treatment plant which can lead to acute or chronic intoxication in treatment process that may significantly decrease process efficiently and even cause damage in biological system.

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INTRODUCTION

Increasing shortage and salinization of freshwater resources is driving many countries to use poor quality water for agriculture and other economic activities. In recent decades, the widespread contamination of surface and groundwater resources, beside increased intellectual awareness of human communities related to the importance of these vulnerable resources have led to extensive efforts to develop effective strategies for preservation of fresh water and restoration of contaminated water. Water contamination is an important indicator of lack of progress in socioeconomic development. Water quality management has been an important issue for decades [3].

In Iran, the industrial development is not compatible with the current environment. As a result, many natural resources such as ground and surface water are contaminated or about to be contaminated. For example, Iranian automotive industry is an intensive energy and material user and produces a product, automobile, that is the single largest contributor to environmental degradation [6]. Also, the Iranian Department of Environment (DoE) declared air and water related problems as the two most Alarming environmental concerns threatening public health in the capital ten years ago [12]. Preventing contamination of water resources is the real key to having a successful environmental management system. The treatment of contaminated water is very hard and costly process. Therefore, preservation of water resources entails identification of areas prone to contamination.

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Vulnerability assessment of water resources could help to define the applied and practical policies for management of these resources and sustainable exploitation of these resources,

Hamadan city is located in the west of Iran, 320 km far from Tehran with a population of about 500,000 [10]. Just as many other metropolises of Iran, the Hamedan traditional market has been witnessing various industrial activities such as wool dyeing, yarn dyeing, wool spinning, yarn spinning, carpet weaving, metal tools production, coppersmith, blocked sugar production, and many other traditional industries. With expansion of urban areas and Rapid expansion of cities and consequent environmental crisis and observing urban standards, the necessity of transferring the industries from urban centers was identified as a strategy for improving the urban environment and quality of life for people within the city. Accordingly, measures have been taken by the Hamedan municipality to transfer the industries from urban areas to industrial parks, which brought successful outcomes. But it seems that some industrial workshops are still acting unlawfully in the city and discharge all the industrial effluents into urban sewage systems. This could pose threats to the surrounding environment. It could also create hardship for treatment process of the site of Hamedan wastewater treatment plant. The presence of heavy metals in municipal wastewater could be an indication of failure of the municipality in transferring variety of heavy industries from urban areas of Hamedan city. The main purpose of this study was analyzed the dissolved Cadmium (Cd), Copper (Cu), Zinc (Zn) and Lead (Pb) concentrations in Hamedan city municipal wastewater and its potential risk to the environment.

MATRERIALS AND METHODS

This research survey was carried out in Hamedan province, during 2012 to 2013. At first, three samples were randomly taken from the Hamedan community wastewater for Pre-Test in April 2013. Based on the pre-test results, the number of required samples was estimated 12. Simple random sampling was the method chosen for this study. Also, the research using grab samples to assess the wastewater quality parameters.

Sampling station was located at the end point of wastewater collection system or nearest manhole to municipal wastewater treatment plant of Hamedan. In case of sampling, first of all, the sampling container was washed twice by wastewater and then filled with wastewater. The wastewater samples were acidified prior to analysis by addition few drops of concentrated high-purity nitric acid. All samples were kept in100 mL polypropylene bottles and stored at 4^{o} C until analyses.

Samples were digested in laboratory with 2.5 mL of concentrated nitric acid and 7.5 mL of concentrated Hydrochloric acid (Merck, Germany). Dissolved metal concentrations (Cu, Zn, Cd and Pb) of the wastewater samples were measured by ICP (Varian ES-710) in ppb. SPSS 18.0 was used in this study for the statistical analysis. The average concentration of each parameter was estimated and compared to the standard. All analyses were performed according to the procedures outlined in standard [1].

RESULTS AND DISCUSSION

Kolmogorov-Smirnov test (K-S test) was used to measure the goodness-of-fit of the distribution. A good fit was obtained for Cd, Pb, Cu and Zn. Means, K-S test indicate that Cd, Pb, Cu and Zn have a normal distribution. (Table 1)

The obtained results showed that, the average concentration of Cd, Pb, Cu and Zn of the samples was 60.98, 44.27, 96.86 and 176.40 ppb, respectively (Table 2).

Statistical studies and regression analyses revealed that there is a significant relationship between Cd and Cu concentrations. This relationship is much stronger than the other two examined in this research. So, the significance level of this relationship is quite acceptable and below 0.05 (Table 3).

In this study, Cd concentration was assumed as independent variable and Cu concentration as a dependent variable. Once again, unlike the previous mood, Cd concentration was regarded as dependent variable and Cu concentration as independent variable. The analyses results indicated that the correlation coefficients and significance levels are not different in the two cases. This means that the concentrations of these two elements are associated with each other. In this statistical analysis it was proved that the correlation coefficient(r) was within acceptable limits, 0.589, in relation with Cu and Cd. This coefficient is far higher than the correlation coefficient among other elements. Based on the results of this study, the concentration of pb and Zn are not associated in any way as the correlation coefficient between these two elements was practically zero and significance level was 0.99, which was greater than 0.05.

Heavy meals are considered as the most important pollutants in the environment due to their persistence, toxicity and bioaccumulation problems. The results of total contents of the studied heavy metals (Cd, Cu, Pb and Zn) in Hamedan community wastewater indicated that the average amount of Cu, Pb and Zn did not exceed Iran maximum permissible limits. One Sample t-Test was used for comparison and the results are shown in table 4.

Table 1: Results of Kolmogorov-Smirnov-Test for normality of original data.

Metal	Cd	Cu	Pb	Zn
N	12	12	12	12
Mean	60.9808	96.8586	44.2742	176.4050
Std. Deviation	93.73824	95.10503	36.99970	127.57296
Kolmogorov-Smirnov Z	1.245	0.817	1.093	0.712
P value[a]	0.090	0.517	0.183	0.692
a. Test distribution is Normal.				

Table 2: Concentration of heavy metals in Hamedan community wastewater ppb.

Metal	n	Min	Max	Ave.	S.E	S.D
Cd	12	0.81	263.19	60.9808	27.05990	93.73824
Cu	12	1.27	267.43	96.8586	27.45446	95.10503
Pb	12	3.78	98.17	44.2742	10.68089	36.99970
Zn	12	37.38	410.34	176.4050	36.82714	127.57296

Table 3: The correction between heavy metals concentration based on analytic results of linear regression model.

Independent variable (ppbPPB)	Dependent variable (ppb)	r	*P* value
Cd	Cu	0.589	0.04
Cd	Pb	0.195	0.54
Cd	Zn	0.057	0.86
Cu	Cd	0.589	0.04
Cu	Pb	0.340	0.28
Cu	Zn	0.180	0.58
Pb	Cd	0.190	0.54
Pb	Cu	0.340	0.28
Pb	Zn	0.001	0.99
Zn	Cd	0.050	0.86
Zn	Cu	0.180	0.58
Zn	Pb	0.001	0.99

Table 4: Results of One Sample t-Tests analysis for compare the metals concentration with Iran maximum permissible limits.

Element	Test Value	t	df	P-value	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Cd	100[a]	1.442	11	0.177	39.01917	98.5776	20.5393
Cd	50[b]	0.406	11	0.693	10.98083	48.5776	70.5393
Cu	1000[a]	32.896	11	0.001	903.14142	963.5683	842.7146
Cu	200[b]	3.757	11	0.003	103.14142	163.5683	42.7146
Pb	1000[a,b]	89.480	11	0.001	955.72583	979.2343	932.2173
Zn	2000[a,b]	49.518	11	0.001	1823.59500	1904.6510	1742.5390
[a] : *standard* for wastewater *reuse* in artificial recharge and disposal in river [b] : *standard* for wastewater *reuse* in *agricultural* irrigation							

Average concentration of Cu, Pb and Zn compared to the approved standard for wastewater reuse in artificial recharge, disposal in river and agricultural irrigation. The results showed that, there was a highly significant difference ($p<0.05$) between the means of Cu, Pb and Zn concentration levels, among the test group, which was lowers, compared to Iran maximum permissible limits (Table 4). From the point of view of Cu, Pb and Zn concentration in Hamedan community wastewater, it can be applied to disposal in surface water, ground water or reuse in agricultural irrigation.

Also, there is no significant difference between the mean of Cd concentration level, among the test grouping, compared to Iran maximum permissible limits (Table 4). Means, discharging the wastewater into the ground or surface water is permitted, although not obligated (table 4). In addition, the mentioned wastewater is not appropriate for agricultural irrigation uses, because the concentration of Cd in Hamedan community wastewater is out of Iran maximum permissible limits.

Karimpour and Shariat [5] reported that the concentration of Cd, Pb and Cr was measured in drinking water in Hamedan city. They found that the amount of mentioned heavy metals available in the drinking water which is supplied from the wells in Bahar plain and Ekbatan Dam exceeds the Iran maximum permissible limits. Rahmani and Shokouhi [8] studied the quality of Bahar plain groundwater in proximity of Hamedan city. They decided to measure some water quality parameters, including Cd, pb, As, Cr, and Ni across Bahar plain over a course of one year. Results showed that the measured amounts of heavy metals are below the Iran maximum permissible limits. On the basis of this finding, no hazard in relation to heavy metals threatens the groundwater of Bahar plain.

Comparable results were obtained by Anh Dao *et al*. [2]. They found the Wastewater characteristic of Hanoi city was polluted and contains a variety of inorganic substances such as Cd (1.09 - 2.14 µg L^{-1}), Cu (0.16

- 0.33 mg L^{-1}), Pb (2.75 - 4.02 µg L^{-1}), Zn (0.20 - 0.34 mg L^{-1}) and Mn (0.22 - 0.44 mg L^{-1}). They concluded that there was a significant quantity of heavy metals, and possible threats to soil biota and then human health. Also, Munir *et al*. (2000) have reported that the wastewater characteristic of Haroonabad town in the southern part of Panjab in Pakistan contains a high amount of Cd, Ni and Pb.

Although heavy metals are natural components of the environment, but its can be accumulated in living tissues and causing various diseases. So it is necessary to identify its source and planning for its control. Such amount of heavy metals in Hamedan community wastewater could be the result of unlawful and illegal activity of some polluting industries across the city as they discharge their effluents into the town wastewater collection system. High amounts of heavy metals in Hamedan community wastewater could also be due to the presence of heavy metals in the drinking water which is urgent need of a separate study.

There are numerous universities and research institutes throughout Hamedan city and mentioned institutes have chemistry laboratories where heavy metal compounds are used. It is therefore likely that the high concentration of some heavy metals in Hamedan community wastewater is caused by the activity of these institutes.

Also, Rastrapal Bansode reported that, Municipal wastewater may be comprises of infiltration/inflow into sewer lines and storm water runoffs. The characteristics of municipal wastewaters vary from location to location depending upon the sources of discharge, the effluents from industries, land uses, groundwater levels, and degree of separation between storm water and sanitary wastes. Most new sewerage systems collect sanitary wastewater and storm wastes separately, whereas older combined systems collect both sanitary wastewater and storm water together. In this situation, the high concentration of some heavy metals in Hamedan community wastewater may be due to contamination of ground water and infiltration into sewer lines and also, kind of sewer collection system.

Hamedan wastewater is collected and then transported to wastewater treatment plant and its treatment system is complete mix activated sludge process. Heavy metals can accumulate in biological systems in wastewater treatment plant which can lead to acute or chronic intoxication in treatment process that may significantly decrease process efficiently and even cause damage in biological system. Means, heavy metals are toxic to most microorganisms' specific concentration and often cause serious upsets in biological wastewater treatment plants. The mechanism by which heavy metals affect the microorganisms is not clear. It has nevertheless been suggested that heavy metals block the enzyme systems of interface with some essential cellular metabolite of bacteria and protozoa. The toxicity of heavy metals in activated sludge mixed liquor depends mainly upon two factors, namely metal specifics and concentration. Other factors such as pH, sludge concentration, influent strength are also reported to affect the toxicity of metals, through to a lesser degree [11].

Based on the results of this study, Hamedan community wastewater contains substantial amounts of heavy metals (Cd, Cu, Pb and Zn). Thus, it is suggested that further studies be conducted to identify the concentration of heavy metals in drinking water of Hamedan city. Also, it is recommended that appropriate studies be performed to determine the concentration of heavy metals that accumulate in the dewatered sewage sludge of Hamedan city, after starting the operation of the wastewater treatment plant. Regarding that Hamedan community wastewater treatment plant was not operated upon the term of this study and the samples were taken before operation of treatment plant; therefore, future researchers are recommended to carry out a carefully study to determine the amount of heavy metals in treated wastewater leaving the plant.

Conclusion:

In this study various statistical techniques were used to evaluate the data. The results of this study were obtained from determination of four wastewater quality parameters of sampling point. The results of this study indicated that, Hamedan community wastewater is not appropriate for agricultural irrigation uses, because the concentration of Cd in Hamedan community wastewater was out of Iran maximum permissible limits. This research led to the development of a new master Plan to prevent, reduce and control pollution of Hamedan community wastewater through the management policies, regulating and monitoring of the waste sector.

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