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A Comparative Study of Light and Heavy Elements Cations in Wastewater in Herat City, Afghanistan

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ABSTRACT

Background: Proper management of wastewater is crucial for the environment. Without knowing the operational status of the treatment system, it is impossible to make an accurate assessment of the system. In this study, the performance of the activated sludge system at the Al-Farooq 207 Qul Urdu (Site A) and Family Center (Site B) wastewater treatment plants was evaluated for the removal of element cations.

Materials and Methods: The research method involved random sampling of sewage. For this purpose, 5 samples were taken from the 2, 3, and 5 meter parts of the distance of 15 samples.

Findings: The concentration of the elements in these wastewaters has been measured and then the results have been analyzed by statistical analysis. After the graphs that were examined and analyzed in the sewage of (Site A) and (Site B) in Herat Province, according to the WHO international standard for these cations of toxic elements such as: Fe^{II} 0.5gr/lit, Al^{III} 0.2gr/lit, Cr^{II} 0. 05gr/lit, Co^{II} 0.023gr/lit, Zn^{II} 3gr/lit, Mn^{II} 0.5gr/lit, Ni^{II} 0.02gr/lit, Cu^{II} 2gr/lit, Cd^{II} 0.03gr/lit, Bi^{II} 1gr/lit, As^{II} 0.01gr/lit, Sb^{II} 0.005gr /lit, Hg^{II} 0.001fr/lit, has determined. The results in the presented graphs are compared with the WHO international range.

Conclusion: The results show that the concentration of toxic cations of heavy elements in the wastewater of (Site A) is very high, except for the remaining (Cu^{II}) cation from the WHO international range. and its use in the fields of agriculture, environment and their flow in surface waters is very worrying. While the concentration of toxic cations of heavy elements in the sewage of (Site B), Herat province, except for the cations of (Zn^{II}), (Mn^{II}), (Cu^{II}), (Cd^{II}), is lower than the WHO international range, the concentration of cations (Fe), (Al^{III}), (Cr^{++}), (Co^{II}), (Ni^{II}), (Bi^{II}), (As^{II}), (Sb^{II}) are relatively high from the WHO international range. And its use in agriculture, the environment and its flow on surface and underground water are worrying. Because this wastewater is used to irrigate fields in Behdaei village of Gozereh district without chemical treatment.

Keywords: Al-Farooq 207 Qul Urdu (Site A), Family Center (Site B), light metals, heavy metals, WHO

INTRODUCTION

In many developing countries, urban communities lack basic services such as solid waste disposal and sewage treatment. Additionally, many industries are not required to comply with environmental regulations. As a result, these communities often suffer from poor health and environmental problems. Large and effective investments are needed to synchronize environmental protection with population growth, economic development, and increasing urbanization (Barton, 1997).

Water pollution from urban and industrial wastewater discharge, the presence of toxic heavy metals, and improper waste management can have dangerous effects on human health. The most common metals found in wastewater are lead, copper, zinc, cadmium, chromium, and nickel. Various methods exist to reduce the amount of metal ions in wastewater, each with its own advantages and disadvantages based on factors such as simplicity, flexibility, effectiveness, cost, technical challenges, and maintenance issues. Among these methods, absorption is considered an efficient process for removing heavy metals from wastewater (Kielinska, 2004). Contamination of water environments and soils with heavy metals is a serious and growing problem (Arnflak, 1996).

The introduction of toxic metals through human activities has polluted many water sources to the point where pollution levels are either above normal or will soon reach that point. Numerous studies have been conducted on the contamination of water, soil, and plants with heavy metals, particularly through irrigation with urban and industrial wastewater or sewage sludge in fields (Flores, 1997). Every day, millions of liters of sewage enter rivers, seas, and soil sources through factories and industrial centers worldwide, polluting the living environment of humans and other living beings including plants and animals (Soltani, 1370). The quality of industrial wastewater varies according to the type of products produced in each industry (Manzavi, 1364).

In the wastewater of chemical and electronics industries, there are various chemicals such as phenols, gasoline, toluene, other hydrocarbons, and various heavy metals, many of which have carcinogenic potential (Dutta, 1997). Sewage sludge is a valuable source of essential plant nutrients. The organic matter in sewage sludge also improves the physical, chemical, and fertility properties of soil (Brollie, 1992). The fertilizer value of sewage sludge has been demonstrated in various studies (Bauer, 1992). Adding sewage sludge to soil increases plant nutrients, especially nitrogen and phosphorus. Sewage sludge can provide a large portion of the nitrogen required by crops (Guag et al., 1995). Some wastewaters have high concentrations of ammonia. The uncontrolled disposal of these wastewaters can cause serious damage to the environment. One such damage is the creation of eutrophication in receiving waters. Since ammonia dissolves quickly in water, it can be one of the worst pollutants that endanger aquatic life (Effler et al., 1990).

One of the most important parameters that affect the nitrification process is the ratio of chemically required oxygen to nitrogen in incoming wastewater. This parameter directly affects competition between autotrophic and heterotrophic microorganisms (Cheng, 1994). This parameter has a more significant effect on the activated sludge process than on the BNR process (Stensel, 1992).

Today there are many technologies available for treating all types of wastewater. These technologies fall into two broad categories: mechanical treatment and natural treatment. The choice of technology depends on factors such as wastewater characteristics, climatic conditions, financial resources, project size, environmental standards, availability of expert human resources, topographical situation of the region, operational capabilities, exploitation methods, welfare conditions, political and social issues of the region and other related parameters can be very different. One of the most important criteria for the design, implementation and operation of wastewater treatment systems is to pay attention to environmental standards, which will have an important contribution in choosing the type of process and other considerations. Because in some areas, despite the possibility of designing and implementing many sewage treatment systems, it may not be possible to design and implement every system due to the existence of strict environmental laws. Also, on the other hand, it is possible that the type of wastewater application and its disposal method and its comparison with environmental standards provide the conditions for the implementation of many wastewater treatment systems. For example, if the wastewater disposal site is receiving tons of water, or tons of agricultural use, or absorption well or a combination of them, it is possible that in the process selection process, design criteria, the way the units are arranged and even the number of units used is effective. Therefore, sufficient attention should always be paid to the way of wastewater disposal and existing environ-mental standards in this regard so that the best decision can be made regarding the management of wastewater treatment (Azimzadeh, 2015).

THE IMPORTANCE OF RESEARCH

Today, as a result of the development of industries and the entry of wastewater from industrial plants, large educational centers, large military centers, etc. into the environment, the ecosystem around these centers and surface and underground waters are at risk of pollution, which in the short term and In the long term, it causes damage to the living organisms of the soil as well as the organisms and plants of these areas.

Cation (which means an ion that has a positive charge), heavy metal elements are among the most common pollutants that are usually found in high concentrations in industrial effluents, causing damage to aquatic environments and endangering the health of living organisms, especially humans.

In human societies, especially industrialized countries, there is no way to avoid heavy metals; For example, in the United States of America, every year, thousands of tons of wastewater and factory effluents containing heavy metals release arsenic, copper, cadmium, nickel, etc. into the soil and then enter the human food chain. Although some heavy metals, such as zinc, play a very important role in the physiological function of living tissue and the regulation of many chemical processes. However, these heavy metals and other metals have toxic effects and biological accumulation on humans and aquatic organisms if they enter the soil in high concentrations through industrial or mining wastewater and as a result human food chain (Mohammadi, 2013).

Site A sewage treatment plant system was built by CONTRACT company in 2003 on behalf of the United States of America, which has several ponds and the ponds are 9 meters deep. There are approximately 8000 to 9000 soldiers and employees in the army corps, and the production waste is treated in the sewage treatment plant. 20,000 cubic meters of water flow into this treatment plant every day and night, and the purpose of building this sewage treatment plant is to purify waste material and reuse it. that all the unnecessary and used water from the kitchen, hospital, toilet, bathrooms and other places after storage under 5 stages, the first stage: garbage collector, the second stage: stored materials settled and sediment they do, the third stage; Liquids in the pool in order to give oxygen and bacteria, the fourth stage: chlorination, the fifth stage: the remaining solid materials are sent to the storage to be turned into fertilizer after some time. Unfortunately, since 2010, this system has failed due to the fact that the ponds are free of bacteria that can decompose waste materials and deposit heavy and light chemical elements, and especially the end of solid chlorine, which is used for this purpose. The mention was not carried out properly and standardly, the untreated water of this sewage was directed out of (Site A) Urdu by the canalization system towards Siyavshan village of Gozrah district of Herat province and a large part of fruitful and unfruitful trees as well as agricultural lands. And it especially damages the fields of rice, wheat, barley, potatoes, vegetables and this issue was very serious and vital and in the future it will cause many health problems for people and especially incurable diseases. Cancer threatens these residents, which has created problems for the military corps due to the above mentioned points.

Examining the heavy elements in these wastewaters is a definite necessity and needs to be investigated, considering the environmental and human effects that pass through the area. This research aims to analyze the cations of heavy and light elements in the sewage of these two places in Herat.

MATERIALS AND METHODS

Due to the trend of population increase in big cities, which naturally causes an increase in urban sewage, the increase in the amount of sewage leaves various defects in the environment of a city or region. Adding heavy metals to water sources, soil and even air is one of the main factors of wastewater. The growing trend of the population in Herat city, migration from other provinces and villages has caused an increase in sewage, and due to the lack of a proper sewage treatment system in Herat, this sewage enters the environment. Lack of attention to the preservation and maintenance of sewage, the lack of a proper sewage treatment system in Herat, the increase in population and the excessive production of sewage in this city, dealing with the issue of sewage and the pollution caused by it, analyzing the amount of elements in this sewage has become an important matter.

After conducting this research, it is very important for Herat's science-loving community and people who are looking for the creation of a city with the best facilities and away from any pollution.

The main objective of this article is to investigate the concentration of light and heavy elements in the wastewater of two regions, and while investigating BOD and COD, the method of chlorination, determining pH is one of the sub-objectives in this article. After conducting this research, it is very important for Herat's science-loving community and people who are looking for the creation of a city with the best facilities and away from any pollution.

THE NATURE, APPROACH AND STRATEGE RESEARCH

In 2022, a research was done about wastewater by the European Investment Bank using a cross-sectional descriptive analysis method. The findings of this research show that every year 380 billion m^3 municipal wastewater are generated globally.

The magazine WHO in a research of sewage pollution in industrialized countries by means of cross-sectional descriptive analysis, states that in North America 90 percent of sewage is treated and this figure for Europe, it is 66 percent, Asia 65 percent, Latin America and the Caribbean region 14 percent, and Africa is less than one percent. In developing countries, between 80 and 90 percent of wastewater is released into the environment untreated or with insufficient treatment.

Research on drinking water has been done by the magazine Indian Institute of Technology Bombay, 2003, which is a cross-sectional quantitative analysis method, and the results show that a total of 36.7 percent of drinking water is treated in Indian cities. And the rest are left raw and unrefined in the surrounding environment. In the big cities of this country, 51 percent, 35.5 percent in big cities, and only 8.7 percent of the produced wastewater is treated in other cities. 50 to 55 percent of wastewater in this country is used for irrigation.

According to the Philippine Sustainable Sanitation Roadmap (2010) Prepared by the National Economic and Development Agency (NEDA) And the Department of Health (DOH), only 10 Percent of the collected wastewater is treated. And the rest are left raw and unrefined in nature (mainly in sea). In Mexico City, 75 cubic meters of urban sewage is produced every second, almost all of which is used to irrigate 85,000 hectares of land.

In the research conducted by United Nation in 2003 under the scope of wastewater treatment and its reuse in developed countries, the method of this research is the famous American method by Photo Spectrometer, and the results show that about 10 Percentage of irrigated lands in developing countries are irrigated with sewage.

A research conducted by M. Bail and H. Tlili in 2019 under the title Removal of Heavy metals from wastewater using infiltration – percolation process and adsorption and Activated Carbon Its results show that: Heavy metal pollution has become one of the most serious environmental problems nowadays. The removal of heavy metals from wastewater has attracted a considerable attention because of their adverse effects on public health and ecosystems. The main objective of this work was to investigate the efficiency of the coupling of infiltration-percolation process with adsorption on activated carbon in the removal of heavy metals contained in urban wastewater effluents. The adsorption of heavy metals on a commercial sample of activated carbon was studied in a static mode. Several laboratory experiments made it possible to distinguish the optimum quantity of powdered activated carbon necessary to remove a large range of heavy metals. Results showed that the equilibrium of the adsorption was reached very quickly for cadmium (Cd^{2+}), i.e., after 15 min of contact with the activated carbon. On the other hand, the equilibrium of zinc (Zn^{2+}), lead (Pb^{2+}) and copper (Cu^{2+}) was achieved after 45 min. The withdrawal rates were 70.77% for Zn^{2+}, 64.75% for Pb^{2+}, 67.07% for Cu^{2+} and 78.42% for $Cd^{2+.}$

The adsorption isotherms determined for Zn^{2+}, Pb^{2+}, Cu^{2+} were of type I, while the shape of the Cd^{2+} curve showed a type II isotherm. These isotherms confirm the capacity of the powdered activated carbon to adsorb cadmium better than the other studied heavy metals.

This research was carried out using the combined approach, random sampling method and experimental method, and the necessary information was collected from the tests, and based on the specific methods considered, they were also analyzed and interpreted in line with the goals and the research questions have been addressed.

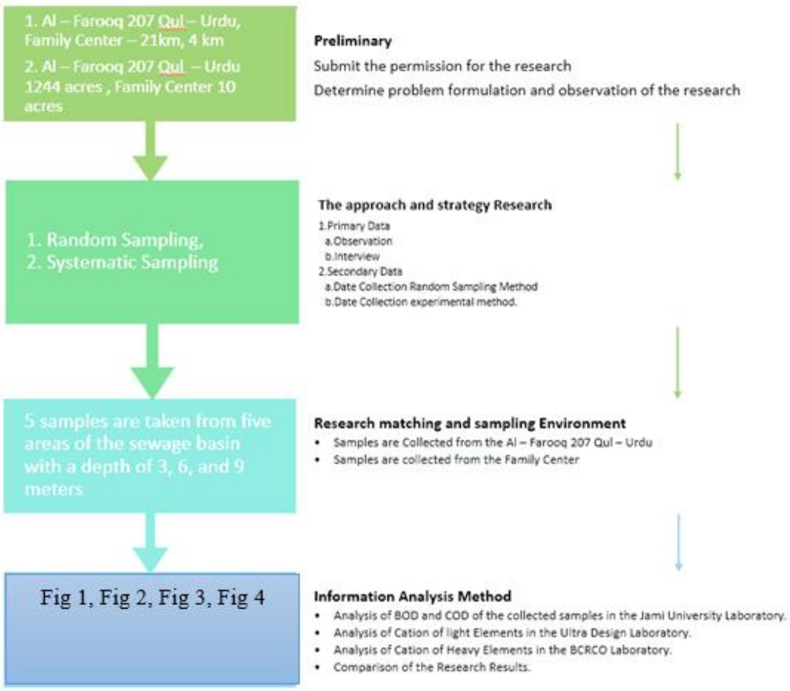
ANALYSIS METHODS

The chemical materials used in this experiment come from Base Consultant Research Corporlion and the wastewater of the Site (A) and Site (B) It was taken from early spring 1401 to winter 1401. Wastewater containing heavy metal was synthesized with the addition of $K_2Cr_2O_7$ and then sterilized for 20 minutes. All the chemical indicators of this research are of analytical quality and were purchased from the company BCRCo.

The number of wastewater samples of Site (A), 15 samples with different concentrations and the number of Site (B) wastewater samples, 12 samples with different concentrations were taken and these samples were mixed in Maxer. And it was analyzed in the laboratory BCRCo.

The samples were passed through a filter 0.45Mm. The cations of different elements such as (Fe^{II}, Al^{III}, Cr^{II}, Co^{II}, Zn^{II}, Mn^{II}, Cu^{II}, Cd^{II}, Bi^{II}, As^{II}, Sb^{II}) were measured with the device Plantest-800 in England Company to check the amount of cations and its concentration in one liter, and also the cations of elements such as (Na, K, Mg^{II}, Ca^{II}, Ba^{II}) was analyzed in the device Plantest-7500 in England Company. In this research, the ion exchange method is used.

Flow chart



RESULTS

Analysis of the research data was also done using Excel software, Faculty of Education Laboratory, Chemistry Laboratory of Engineering Faculty of Jami University and the Ultra Design and Research Company Laboratory Department/ Water Section, and Base Consultant & Research Corporation, which was done to identify the factors affecting the research topic.

Field research tools consisted of: Special bottles containing 0.001 percent nitric acid (HNO_3), Gloves, Mask, Pipette and laboratory research equipment: Special reagents for elements cations, Analyzed water, Multi Ter Meter, Kit Delqoua, pH, Sampler tip, Mixer, Bekar, Test tube, Micro Pipette, Centrifuge, Heat source, Metal catch, Sensitive scales 0.001 g, Gloves, Mask, Test of Palin tes 8000 and 7500.

Figure 1 shows the concentration of cations of light elements such as sodium, potassium, calcium, and barium in the wastewater of (Site A), Herat province, from the international standard (WHO) is high. Magnesium cation is below the international standard (WHO). Figure 2 shows the concentration of cations of heavy elements, except copper, is above the international range (WHO). Figure 3 shows the concentration of cations of light elements in the sewage of (Site B), Herat Province is all above the international range (WHO). Figure 4 shows the concentration of heavy element cations in the sewage of (Site B), Herat province, including the cations of zinc, manganese, copper, and cadmium, is below the WHO international range. And the rest of the WHO international range is high. Figure 5 shows the comparing the amount of light elements in the sewage of Site A and Site B, Herat Province, the amount of potassium and magnesium elements in Site B was low compared to the amount of magnesium and potassium cations in Site B. Also, the amount of sodium, calcium and barium cations in Site A is higher than the sodium, calcium and barium cations in Site B. Figure 6 shows the set of cations is higher in the wastewater of Site A compared to Site B.

After examining and analyzing the Figures in the sewage of Site A and Site B in Herat Province according to the WHO international standard for these cations of toxic elements such as: Fe 0.5gr/lit, Al 0.2gr/lit, Cr 0.05gr/lit, Co 0.023gr/lit, Zn 3gr/lit, Mn 0.5gr/lit, Ni 0.02gr/lit, Cu 2gr/lit, Cd 0.03gr/lit, Bi 1gr/lit, As 0.01gr/lit, Sb 0.005gr/lit and Hg 0.001gr/lit. The results in the presented graphs are compared with the WHO international range. The results show that the concentration of toxic cations of heavy elements in the wastewater of Site A is very high, except for copper (Cu) cation which is within the WHO international range. Its use in agriculture and environment and its flow in surface waters is very worrying. While the concentration of toxic cations of heavy elements in the sewage of Site B in Herat Province is lower than the WHO international range for zinc (Zn), manganese (Mn), copper (Cu), and cadmium (Cd) cations, the concentration of iron (Fe), aluminum (Al), chromium (Cr), cobalt (Co), nickel (Ni), bismuth (Bi), arsenic (As), and antimony (Sb) cations are relatively high from the WHO international range.

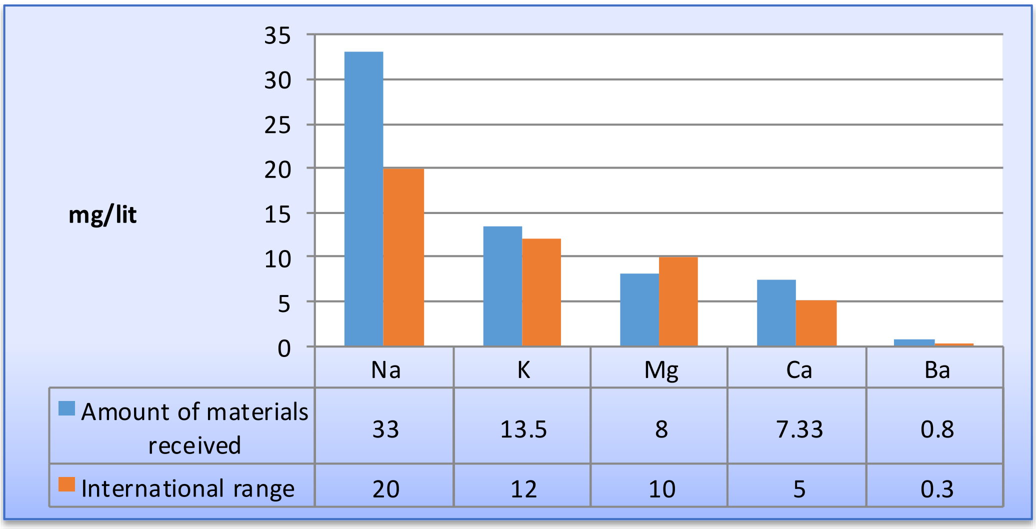


Figure 1. The amount of cations of light elements in the wastewater of (Site A)

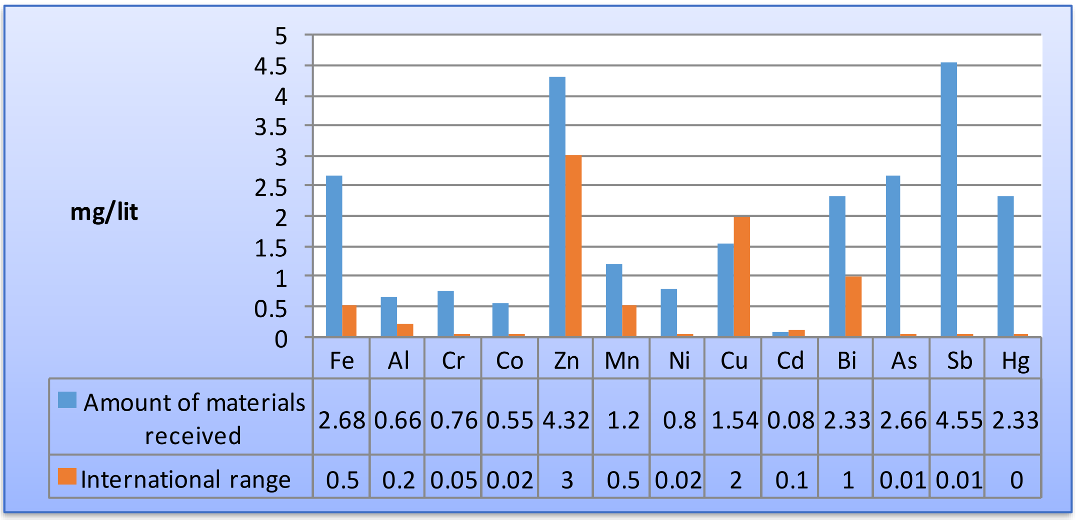


Figure 2. The amount of cations of heavy elements in the wastewater of Site (A)

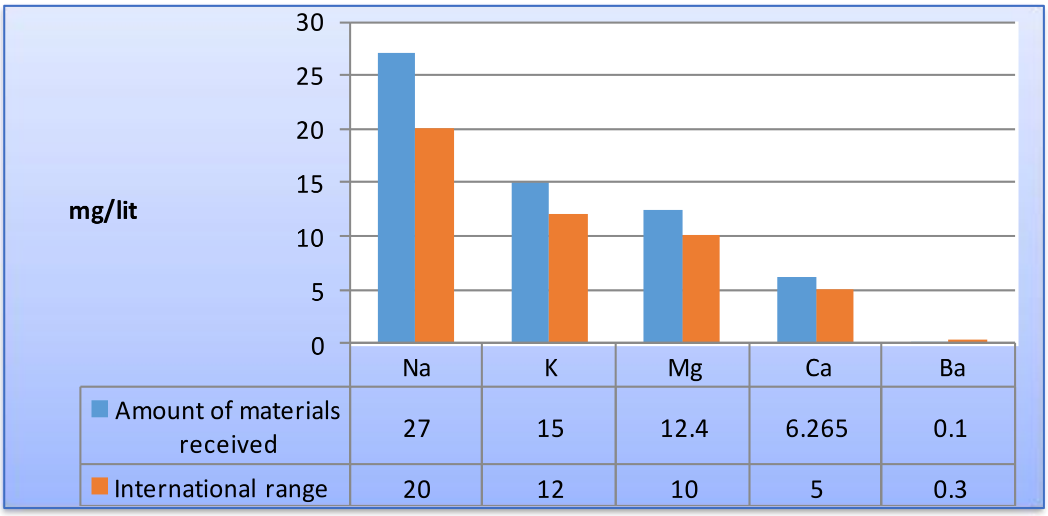


Figure 3. The amount of cations of light elements in the sewage of (Site B).

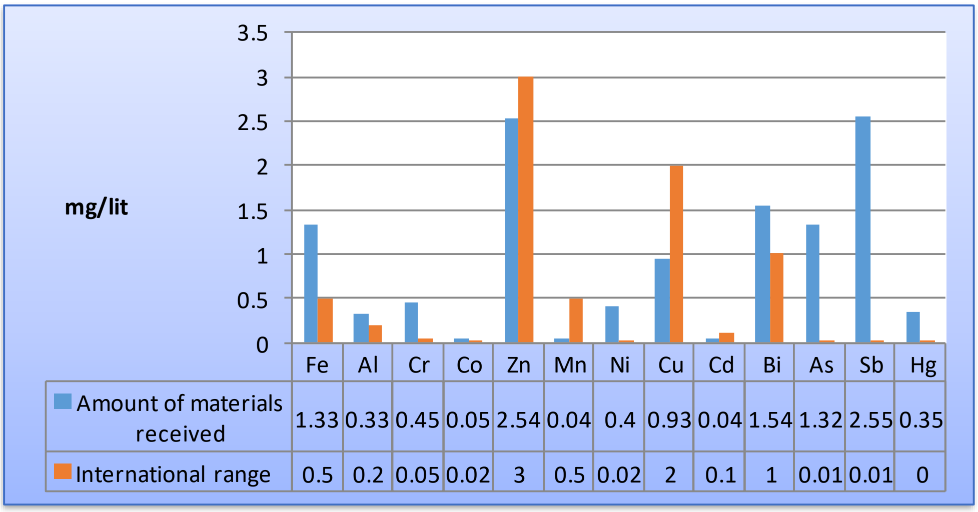


Figure 4. The amount of cations of heavy elements in the sewage of (Site B).

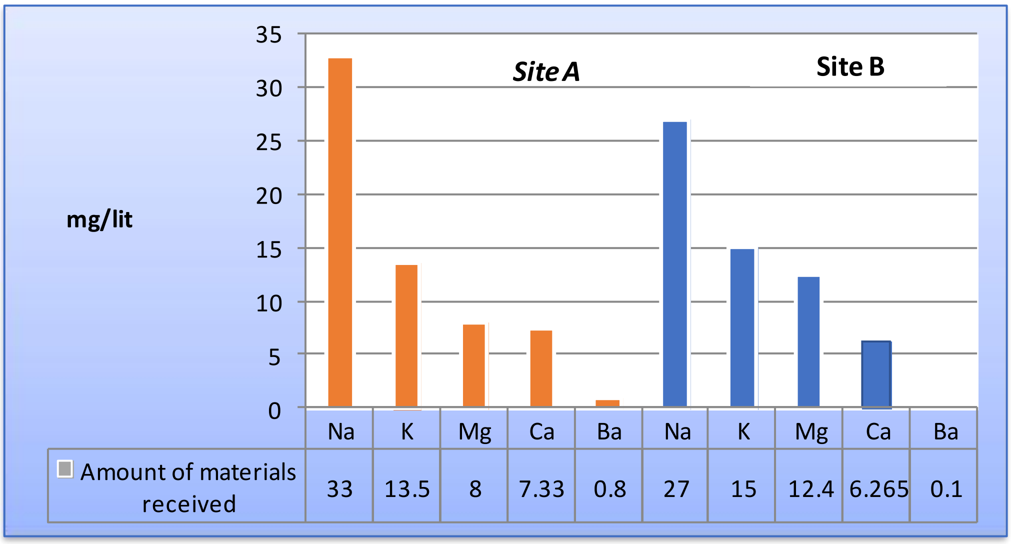


Figure 5. Comparison of light elements in the sewage of (Site A) and (Site B).

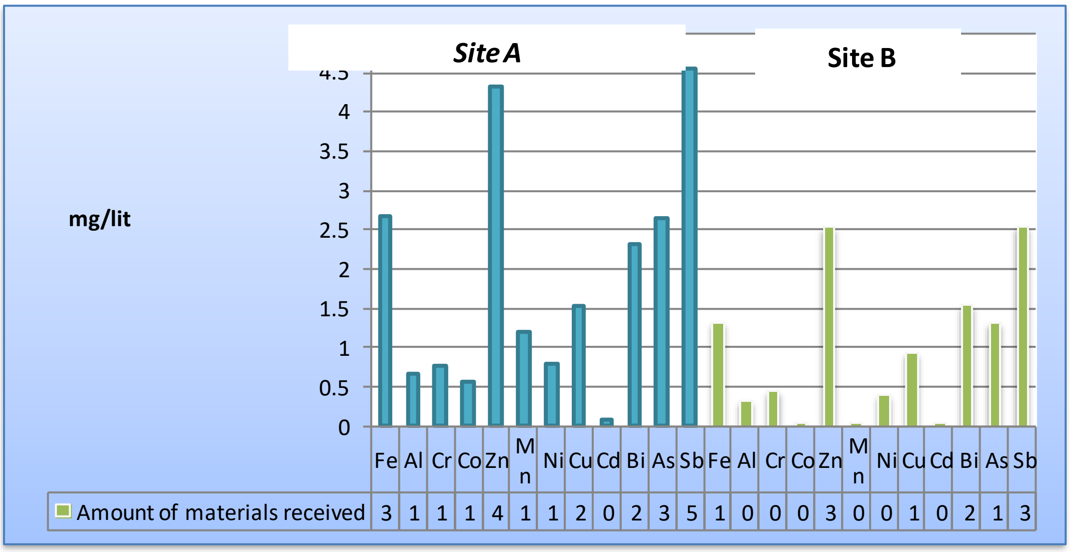


Figure 6. Comparing the amount of heavy elements in the sewage of Site A and Site B

DISCUSSION AND LIMIRATION OF THE RESEARCH

A field study conducted by Rajkumar Herojeet, Madhuri S.Rishi, and Naval Kishore in 2015 titled "Integrated approach of heavy metal pollution indices and complexity quantification using chemometric models in the Sirsa Basin, Nalagarh valley, Himachal Pradesh, India" applied chemometric techniques and pollution assessment indices to determine the source and intensity of pollution in the Sirsa River, Himachal Pradesh, India. Results show that EC, Cr, Fe, Mn, and Ni were above the permissible limit as per the Bureau of Indian Standards. The heavy metal pollution index (HPI) and contamination index (Cd) provided contrasting outcomes and poor correlation was observed. A heavy metal evaluation index (HEI) method was developed using a multiple of mean and correlation coefficient values to provide an alternative pollution classification. The criteria of HEI adopted for reclassification of HPI and Cd produced comparable results; 40% of samples were labeled as low contamination, 50% as medium contamination, and 10% as high contamination for all indices. Principal component analysis along with cluster analysis was used to identify the main factors responsible for degradation of water quality: discharge of industrial effluent, river bed mining, agricultural runoff, and minor natural or geogenic input. The methods and chemo metric study proposed here can be used as effective tools to gather information about water quality and water resource management.

A field study conducted by Yan Sun and et, al in 2020 titled "Efficient removal of heavy metals by synergistic action of microorganisms and waste molasses" In this study, two bacteria strains (Enterobacter sp. SL and Acinetobacter sp. SL-1) and waste molasses (carbon source) were used to remove Zn (II), Cd(II), Cr(VI), and Cr(Total) in the liquid solution (87 mg・ L). The results showed the removal efficiencies of Cr (Total) and Cr (VI) could reach over 98.00% after reaction, and the removal efficiencies of Zn (II) and Cd (II) were all about 90.00% by the synergistic actions of microorganisms and waste molasses. In this process, waste molasses provides nutrients for microorganisms and has the characteristics and capability of Cr, Zn, and Cd. Microorganisms mainly use biological adsorption (36.95% and 45.69%) and metabolism24.37% and 17.05% by producing) humic-acid and folic-acid like substances) to remove Zn(II) and Cd (II), while waste molasses could to remove Cr(Total) (81.24%) and Cr(VI) (75.90%). This study has potential application value for the treatment of wastewater containing high concentrations of heavy metals.

A field study conducted by Zhe Xu and et,al in 2022 titled " A critical review on chemical analysis of heavy metal complexes in water/ wastewater and the mechanism of treatment methods" In this study, Efficient mitigation of toxic and recalcitrant heavy metal complexes (HMCs) from water and wastewater is critical to guarantee the environmental health and safety, but still faces many challenges. Although a number of techniques have been developed to deal with HMCs laden water/wastewater, there is still a lack of comprehensive and insightful understanding of the relevant mechanisms. One of the main reasons is the complicated heavy metal speciation in water/wastewater, which masks the speciation distribution and coordination circumstance of heavy metals. In this review, prevalent methods for HMC elimination (e.g., physical separation and chemical decomplexation) are briefly presented and evaluated. Especially, the characterization methods of HMCs, which afford to provide valuable information on the speciation distribution of heavy metals, are underlined and discussed. Furthermore, typical cases are provided to elucidate the essential role of species transformation in the decomplexation of HMCs and the implications for enhanced mitigation of HMCs are also discussed. Finally, the current challenges and perspectives for future study in this field are proposed.

A lot of research has been done on wastewater and its retreatment. However, by examining several research studies, results show that researchers have found that the concentration of heavy elements in all wastewaters is high. Also, the amount of reuse of these wastewaters is also done in developing countries. This research is almost similar to the field research conducted on the sewage at Site A and Site B. The amount of light and heavy elements in the sewage at Site A and Site B is higher than normal which causes serious problems for health as well as plants.

One of the other differences between Mayan's research and the research conducted by Yan Sun and et al in 2020 is the use of a biological method to effectively remove microorganisms, which in our research is measured by the ion method.

One of the differences between this research and other researches is that other researches have only received the concentration of one or three heavy elements in wastewater, but in this research all light and heavy elements have been worked on. One of the other prominent features of this research that makes it different from other researches is the amount of arsenic in wastewater, which was not done by other researchers. Another feature of this research is its effectiveness and purposefulness, which has never been done by any researcher in the western region regarding sewage.

By doing this research and knowing the indicators of sewage and the cations in it for the residents of residential areas who live around these two sewers, it can be an effective solution to prevent the use of sewage in agricultural fields. and its use for productive and non-productive factories, as well as the re-standardization of effluents in a standardized manner in such a way that it can reduce light and heavy metals as much as possible, the government should consider a new approach, so that the people of the region who Those who use this wastewater, especially the village of Behdaei in Gozrah district of Herat province, which is the main source of its use, should be informed about its use or non-use.

Recently, it is suggested to publicize this article in a scientific conference at the country level, so that the relevant officials take serious action to revive these two effluents so that they can be used and exploited in the form of international standards. Future research studies should focus on environmentally friendly, cost-effective and sustainable materials and methods. And also, a wider field research should be done using the national budget so that the high concentration of toxic elements that break down in the form of ion exchange can be determined and suitable solutions can be provided to reduce it.

CONCLUSION

The correct sewage treatment system is one of the most important solutions in creating sewage so that it can reduce the concentration of light and heavy elements in it. Keeping in mind the current research on the concentration of cations of light and heavy elements in the wastewater of sites A and B in Herat province, considering that these two wastewaters have inadequate treatment systems, the concentration of elements in them according to the international standards international level is high, and this can cause serious problems in the agricultural sector, for productive and non-productive plants, and also harmful for human health, because most of the cations of heavy elements are toxic and carcinogenic. It enters the human body through the food chain; it can cause various diseases in the body with the use of grains and legumes that are irrigated with these wastewaters. One of the most basic problems in the non-treatment of these wastewaters is the lack of BOD and COD systems, which must be revived and activated in the wastewater of Site A and Site B.

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