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Combination of Bio-Adsorbent for enhanced removal of lead from Aqueous Solution

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ABSTRACT

Nowadays due to increasing industrialization and using the batteries in large scale by the humans have increased the rate of Lead (Pb-II) that are contributing in increased impact on health as well as environment. The increased toxicity and growth inhibition of living things are being caused by the excessive concentration of Lead directly disposed to the river streams. The efficiency of combined activated Moringa seeds and Tea waste as an adsorbent were tested for the removal of lead from industrial wastewater. By creating the 0.5-cm diameter column and height 14-cm. Different Adsorbent doses were used (1, 2 and 4 g/L) having different flow rates (1, 2 and 4 ml/min). The combined activated bio-adsorbent showed better results when comparing with the tea waste and moringa seed results separately. The saturated column material can be regenerated and reused. The maximum adsorption capacity was found at 4g/L feed concentration and 1 mL/min flow rate .The results of lead (Pb-II) concentration were obtained through Atomic Absorption Spectrophotometer.

Keywords:

Lead
Moringa Seed
Tea Waste
Bio-Adsorbent
AAS

1. Introduction

Due to discharge of contaminated industrial wastes into lands, rivers and lakes it causes the pollution of water bodies with heavy metals. Soil contamination has also increased by heavy metals which have caused threat to human life as well as environment [1]. The present study in Pakistan has shown the increasing of heavy metals such as lead due to less utilization of the environmental regulations to manage the untreated discharge of toxic metals resulting in causing diseases among the human beings[2]. There are lots of health hazards caused by lead leading to abdominal pain, headache, dizziness, fatigue [3]. E-waste and house hold lead dust is a major cause for lead poisoning, the dust containing lead easily reach in the system of adsorbents making them more prone to lead causing[4-6]. Lead poisoning is common in those working as painters, smelters, compositors, auto mechanics and miners[7]. Children are more susceptible to lead poisoning via dust and other sources of lead stored improperly resulting in neurological disorders[8]. The lead toxicity impairs the spatial memory [9]. There are various sources which can cause lead poisoning such as Lead gets embedded in various plastics such as polyolefin and polyvinylchloride, which eventually end up marine and fresh water sources [10]. The wastewater from tanneries often contains lead which is used for various tanning processes [11].The urbanization and the usage of lead-based paints for various household decorations, the gasoline and plumbing of lead pipes cause lead deposition [12, 13]. In past lead acetate was used as artificial sweetener for wine and for household flavorings, some of the lead compounds were also used for various medical purposes in Indian and Chinese traditional medicines [14].There have been many methods used for treating Lead(Pb-II) such as adsorption, coagulation/flocculation. Electro-chemical, Oxidation, Electro-Coagulation. Adsorption has numerous advantages over alternate methods such as membrane processes, sedimentation and Ion-Exchange. As adsorption has better features including easy accessibility and is less costly and much effective replacement technology for traditional technologies [15]and includes much higher removal efficiency and simple operation[16]. Due to several parameters adsorption has put out much influence such as feed concentration, mixing time, pH and temperature [17]. Adsorption methods have been used by many in order to remove different types of metals for water treatment. There are many low cost materials available which have given better results to remove lead from waste water which includes (Clay, Sapropel, Talc, barite, chalcopyrite, peanut shell, prosopis juliflora, Eggshell, Rice Husk and Iron Sludge. (Ghayda Y.Al kindi et.al 2020) worked on successful removal of lead using low cost adsorbent Moringa seed[18]. (L.M.Mataka et.al 2006) used moringa seeds for lead contaminated water and got the results upto 95 %[19]. (A.K.Gautam et.al 2020) worked on different natural occurring adsorbents including moringa seeds and got an effective result of 86 % removal of lead from textile wastewater[20]. (B.M.W.P.K.Amarasinghe and R.A Williams 2007) experimented on Tea waste and concluded that it removes upto 90 % lead from wastewater r[21]. Manoj Kumar Mondal 2009 used activated tea waste for lead removal and found 99.7 % to be removed from aqueous solution [22]. As the previous studies have shown that Moringa seeds and Tea waste has better results than all other natural occurring adsorbents so these two were selected to work on as hybrid. As natural occurring adsorbents have higher efficiency of lead removal than chemical coagulants. Wastewater is the water that has been used once by any particular, industrial process or any domestically used. Waste water is broadly divided into two main categories either it is sewage waste water or non-sewage waste water. Any waste water that comes from domestic activities which includes houses, public toilets, restaurants, schools, hotels and hospitals and non-sewage wastewater contains water that comes commercially from activities of garages, laundries and water from industrial plants. Wastewater contains different heavy metals including Lead (Pb), Copper (Cu), Zinc (Zn), Chromium (Cr) and many other impurities like pH, Total dissolved solvents (TDS), Total suspended solids (TSS) and Bio-Chemical Oxygen Demand (BOD). According to World Health Organization (WHO) the permeable limit for lead in drinking water should not be more than 15 µg/L. The battery manufacturing industries, dying industries, tanneries. In Pakistan, according to recent studies lead contamination has been increased due to industries not treating the waste water and mostly releases effluent contained waste water into the rivers. 150 ppb of Lead (Pb) has been detected in the Karachi industrial area.

The novelty of this research is to check the combined effect of moringa seed and Tea waste used as bio-adsorbent. These two naturally occurring moringa seed and tea waste are locally available and the method is also very easy and cost effective.

2. Materials and Methods

2.1. Collection of Adsorbents

The ripe and dried pods of Moringa seeds were collected locally from Larkana, Sindh, Pakistan. The seeds were carefully removed from the pods by splitting the pods. The seeds were categorized upon their size, the small and malformed seeds were discarded. The normal sized seeds were de-husked by hand and seeds were collected. The de-husked seeds were washed for many times with distilled water in order to remove dust and excess material. The washed seeds were Sun-dried first and then were kept in vacuum desiccator till further use.

The Tea waste was collected locally from the canteens of Mehran University of Engineering and Technology (MUET) Jamshoro, Sindh, Pakistan. The tea waste was washed several times with distilled water in order to remove dust and other physical impurities and was collected over filter paper and was also kept in vacuum desiccator. Both of these adsorbents were then crushed to exact size of 1mm using hammer machine and were sieved through sieve shaker to obtain exact particle size of adsorbents.

2.2. Activation of Adsorbents

The known amount of 250 grams of each moringa seeds and Tea waste were than selected for activation purpose.

Activation of Moringa Seeds

After Pre-Treatment, Activation of moringa seeds was done by chemical method using zinc chloride ($ZnCl_2$). The sulfuric acid (H_2SO_4 =98.08%) was used to activate the Moringa seed with (1:10) ratio and 30 gram of raw material was saturated in 300 ml with 10% (H_2S0_4) (v/v) and 10% $ZnCl_2$(w/v) and was continuously mixed by magnetic stirrer for 3 hours and then were settled for 24 hours, then dried at 100ºC for 2 hours and was stored in vacuum desiccator till further use (Fig. 01).

Activation of Tea Waste

After Pre-treatment, Activation of tea waste was done by chemical method using Sodium Sulphide (Na_2S) to enrich the Sulfur content. 250 grams of Tea waste was immersed in deionized distilled water containing 0.5 grams of Sodium Sulfide (Na_2S) was mixed for 3 hours using magnetic stirrer and were settled for 24 hours, then dried at 100ºC for 2 hours and was stored in vacuum desiccator till further use (Fig. 02).

2.3. Adsorbent Characterization

The rate of Pb-(II) pollutants being removed from wastewater by an adsorbent is momentously affected by physio-chemical nature of the natural occurring adsorbents. Therefore, before using any adsorbent it should be characterized for determining its relevant chemical composition and physical properties.

Fourier Transform Infrared Spectroscopy (FTIR) studies were done in order to know the development of functional groups and structure of Activated Moringa seed and Tea waste.

Activated Moringa seed and Tea waste was analyzed and tested through Scanning Electron Microscope (SEM) to know the surface morphology of adsorbent.

2.4. Lead Solution

The Lead Stock solution was prepared by dissolving 0.154 gram Lead Acetate Trihydrate in deionized distilled water. The stock solution was then diluted with distilled water in order to obtain desired concentration of lead 10 ppm.

Fig. 01: Activation of Moringa Seed

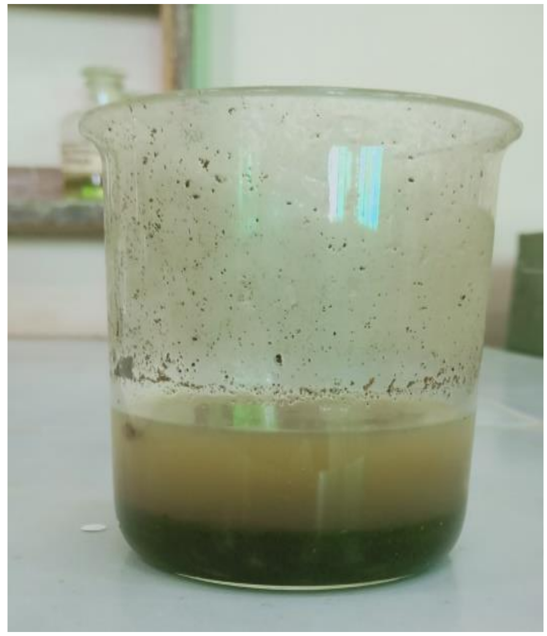

Fig. 02: Activation of Tea Waste

2.5. Lead Determination

The Lead concentration solutions were determined through Atomic adsorption spectrophotometer using flame Technology. The Lead standards were prepared were checked with standard reference material attained from National Bureau of Standards, USA.

2.6. Column Study

Column made of borosilicate glass having 14cm height and 0.5cm diameter was used. Column was mounted vertically and Glass wool was used as a supporting material for adsorbent fixed at center of the column and also serves the purpose of filtration of adsorbent particle. Experiment was conducted at three different adsorbent dosages (1, 2 and 4 grams) and different flow rates (1, 2 and 4ml/min). The flow rates were controlled through peristaltic pump. When the flow rate is particularly maintained, the feed containing initial concentration of Pb (II) (10 ppm) is introduced in the column. The sample was collected after every 1 hour. The experiment was conducted at room temperature.

3. Results and Discussion

The experimental work was conducted to know the optimum dosage of naturally occurring moringa seed and tea waste as a bio adsorbent for maximum efficiency of Lead removal.

The result shows that the best naturally occurring moringa seeds and tea waste used as a bio adsorbents for removing Lead metal are much cheaper and more environmental friendly.

Scanning Electron Microscope (SEM) was used to know the morphological structure of Moringa seed and Tea waste. Figs. 03-04 show the pores and surface roughness.

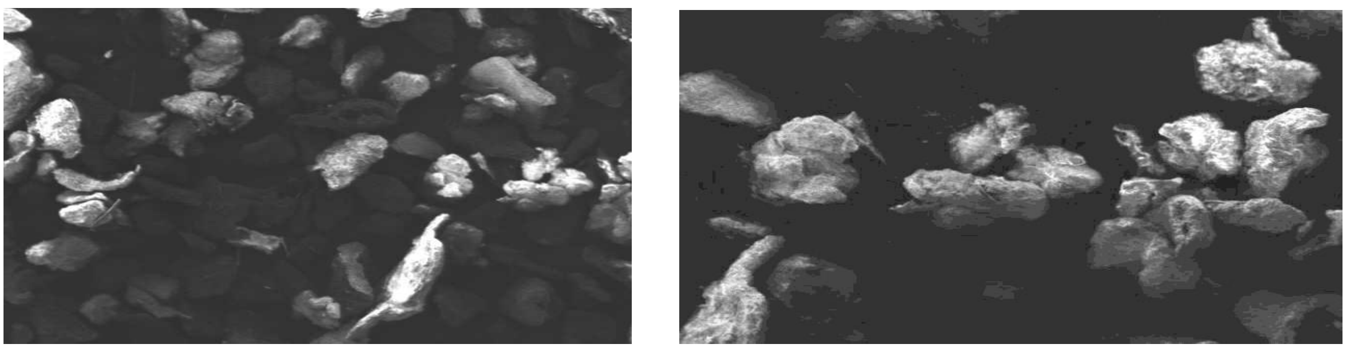

Fig. 03: SEM image for Activated Combined Bio-Adsorbents before Use

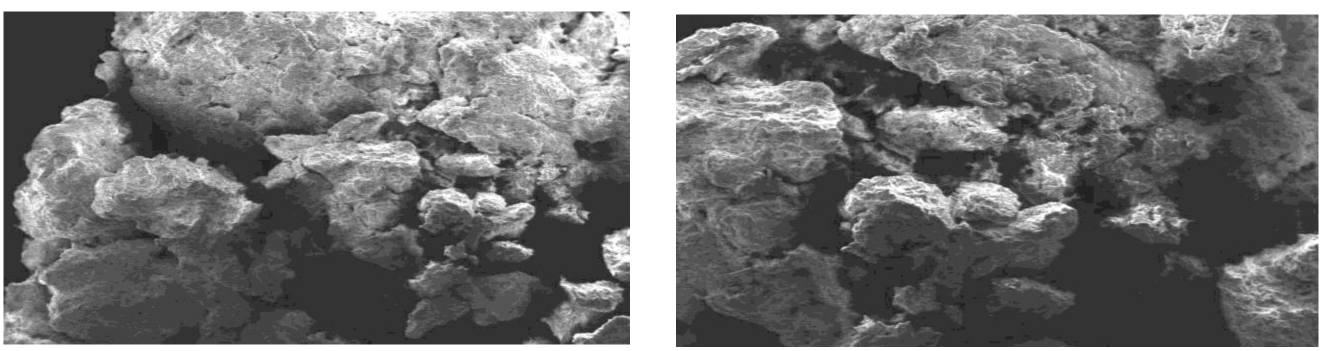

Fig. 04: SEM image for Activated Combined Bio-Adsorbents after Use

Scanning Electron Microscope images clearly shows the increase of pores sizes which will directly increase the adsorption process.

After the adsorption process it clearly indicates the change in surface morphology as before adsorption the surface morphology appears smooth and uniform. The Lead Pb-(II) present in water was removed and was attached to the surface of bio-adsorbents this was the reason that the adsorbent surface was rough after adsorption process.

Fourier Transform Infrared Spectroscopy (FT-IR) was used in order to know the IR spectrum of the natural occurring bio adsorbents in powdered form (Figs. 05-06).

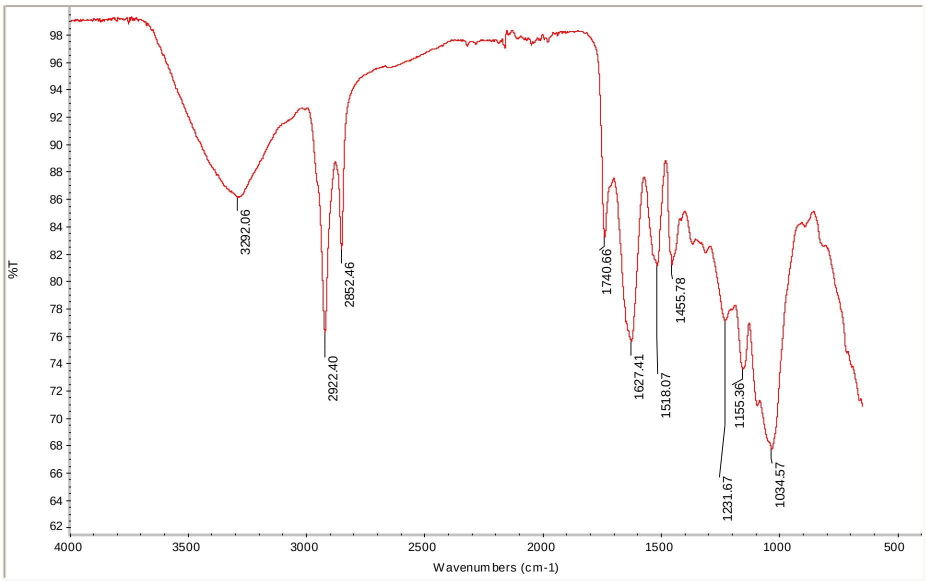

Fig. 05: FT-IR spectrum of combined Bio-adsorbents

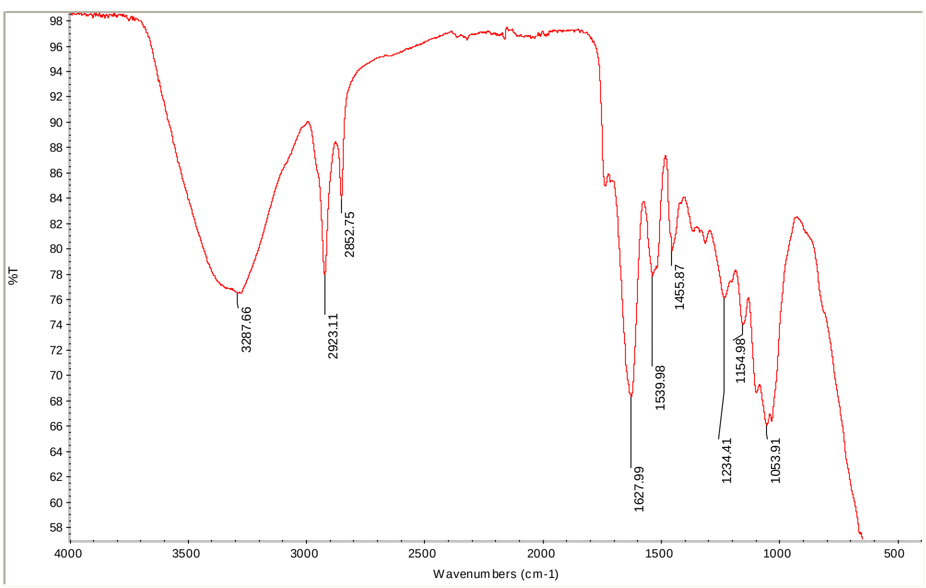

Fig. 06: FT-IR spectrum After Activation of combined Bio-adsorbents

FTIR study was done to know the functional groups development. There was a change in spectrum after the activation of bio-adsorbent.

3.1. Effect of Bio-Adsorbent Dose on Lead Removal

The prepared solutions with the initial concentration of 10 ppm were loaded with three different dosages of (1, 2 and 4) gram. The removal percentage by the bio-adsorbent was determined. Figs. 07-09 show the 3 lead solutions with an initial Lead concentration of 10ppm loaded with 3 different doses. The highest removal efficiency was achieved at 4 gram dosage. It was observed that by increasing the bio adsorbent dose will increase the removal efficiency. The highest removal efficiency achieved at 4 gram was 96.95%.

3.2. Effect of Bed Height

The effect of bed height was observed with three different bed heights of (2, 4 & 8) cm. The bed height played an important role as the bed height was increased the removal efficiency was also increased. The highest removal efficiency was achieved at 8 cm bed height.

3.3. Effect of Flow rate

The effect of flow rate was also observed with three different flow rates of (1, 2 &4) ml/min. By observing the different flow rates it was known that the results were even better when the flow rate was lower. The highest removal efficiency was achieved at 1 ml/min.

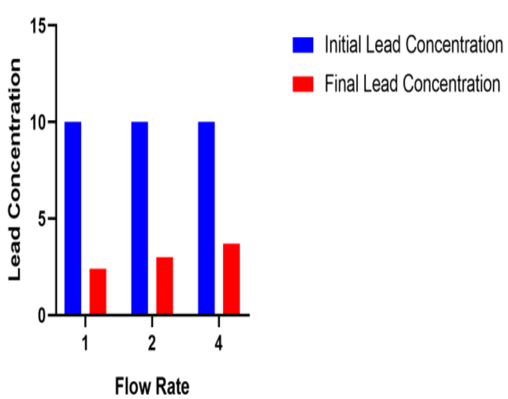

Fig. 07: Bio Adsorbent dose of 1g/L.

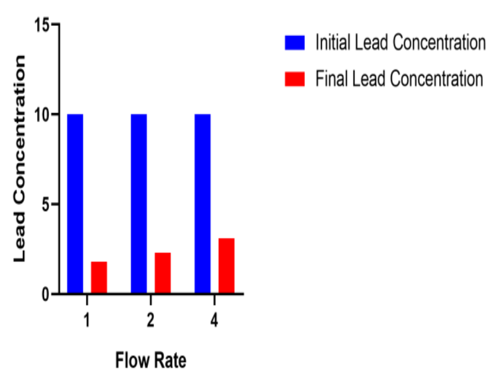

Fig. 08: Bio Adsorbent dose of 2g/L.

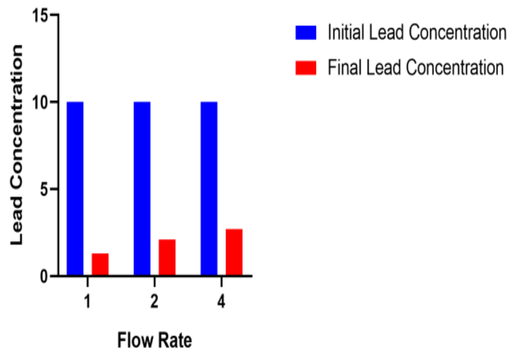

Fig. 09: Bio Adsorbent dose of 4g/L.

4. Conclusion

The sole purpose of this research was to introduce such a bio-adsorbent which is of low-cost and highly effective in terms of results when compared to other adsorbents. The continuous study of the filtration was observed in order to check the effectiveness of the bio-adsorbent.

It was observed that combined bio-adsorbent of Moringa seed and Tea waste has better results when compared to other adsorbents. The adsorption was also affected by flow rate and adsorbent dose. Hence, by changing any parameter the results would be changed. It was noticed that by increasing the flow rates will decrease the removal efficiency of Lead (Pb-II). So, by maintaining the lowest possible flow rate of 1 ml/min will give the maximum results i.e.: 96.95%.

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References

[1] Shen, Z. and *et al.*. Effect of production temperature on lead removal mechanisms by rice straw biochars. *Science of the Total Environment*, 2019. 655: P. 751-758.

[2] Imran, U. and *et al.*. Health risk assessment of the exposure of heavy metal contamination in surface water of lower Sindh, Pakistan. *SN Applied Sciences*, 2019. 1(6): P. 1-10.

[3] Ge, W. and *et al.*. Severe Abdominal Pain as a Presentation of Lead Poisoning: a Case Report. 2021.

[4] Braun, J.M. and *et al.*. Residential dust lead levels and the risk of childhood lead poisoning in United States children. *Pediatric research*, 2020: P. 1-7.

[5] O'Connor, D. and *et al.*. The effects of iniquitous lead exposure on health. *Nature Sustainability*, 2020. 3(2): p. 77-79.

[6] Zeng, X. and *et al.*. E-waste lead exposure and children's health in China. *Science of The Total Environment*, 2020. 734: P. 139286.

[7] Mani, M.S. and *et al.*. Challenges in diagnosing lead poisoning: A review of occupationally and nonoccupationally exposed cases reported in India. *Toxicology and Industrial Health*, 2020. 36(5): P. 346-355.

[8] Naranjo, V.I. and *et al.*. Lead toxicity in children: an unremitting public health problem. *Pediatric Neurology*, 2020.

[9] Soodi, M. and *et al.*. Systemic and developmental exposure to lead causes spatial memory deficits and a reduction in COX-2 immunoreactivity in the hippocampus of male rats. *Journal of neuroscience research*, 2007. 85(14): P. 3183-3192.

[10] Turner, A. and *et al.*. Metals and marine microplastics: Adsorption from the environment versus addition during manufacture, exemplified with lead. *Water research*, 2020. 173: P. 115577.

[11] Marzan, L.W. and *et al.*. Isolation and biochemical characterization of heavy-metal resistant bacteria from tannery effluent in Chittagong city, Bangladesh: Bioremediation viewpoint. *The Egyptian Journal of Aquatic Research*, 2017. 43(1): P. 65-74.

[12] Levin, R. and *et al.*. Lead seasonality in humans, animals, and the natural environment. *Environmental research*, 2020. 180: p. 108797.

[13] Levin, R. and *et al.*. The urban lead (Pb) burden in humans, animals and the natural environment. *Environmental Research*, 2020: P. 110377.

[14] Mahuta, M.A. An overlook of sources and strategies of minimizing lead poisoning in Nigeria. *Journal of Humanities and Social Sciences*, 2020. 20(6): p. 330-340.

[15] Srinivasan, R. Advances in application of natural clay and its composites in removal of biological, organic, and inorganic contaminants from drinking water. *Advances in Materials Science and Engineering*, 2011. 2011.

[16] Owlad, M. and *et al.*. Removal of hexavalent chromium-contaminated water and wastewater: a review. Water, air, and soil pollution, 2009. 200(1): P. 59-77.

[17] El-Maghrabi, H.H. and *et al.*. Removal of heavy metals via adsorption using natural clay material. *Journal of Environment and Earth Science*, 2014. 4(19): P. 38-46.

[18] Al Kindi, G.Y. and *et al.*. Combined adsorbent best (chemical and natural) coagulation process for removing some heavy metals from wastewater. *International Journal of Environmental Science and Technology*, 2020. 17(7): P. 3431-3448.

[19] Mataka, L. and *et al.*. Lead remediation of contaminated water using Moringa Stenopetala and Moringa oleifera seed powder. *International Journal of Environmental Science & Technology*, 2006. 3(2): P. 131-139.

[20] Gautam, A. and *et al.*. Lead removal efficiency of various natural adsorbents (Moringa oleifera, Prosopis juliflora, peanut shell) from textile wastewater. *SN Applied Sciences*, 2020. 2(2): P. 1-11.

[21] Amarasinghe, B. and *et al.*. Tea waste as a low cost adsorbent for the removal of Cu and Pb from wastewater. Chemical engineering journal, 2007. 132(1-3): P. 299-309.

[22] Mondal, M. Removal of Pb (II) ions from aqueous solution using activated tea waste: Adsorption on a fixed-bed column. *Journal of environmental management*, 2009. 90(11): P. 3266-3271.