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Application of nanoparticles for the removal of heavy metals from wastewater

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Abstract
Heavy metals along with diverse chemicals, released from different anthropogenic sources are alarmingly contaminating drinking water which has become a global concern. Quality of drinking water in Pakistan is overlooked, poorly monitored and managed both surface and groundwater drinking water sources are being contaminated. This drinking water being polluted is relatively a new problem directly related to unprecedented growth in population, urbanization, and industrialization in recent years as a result stress is arising. Human health and environment face major consequences due to this contamination of water resources. To combat these problems and to meet the basic human right of safe drinking water, novel water treatment technologies are emerging. Developing sustainable methods for water treatment is a major concern. Nanotechnology is one of its kind in this perspective. This technology has immense potential to restore polluted water efficiently and effectively. The present study's aim was to determine the potential of Green synthesized iron oxide nanoparticles for the removal of heavy metals from wastewater

Keywords: Nanoparticles, agriculture waste, heavy metals, water

Introduction
Water is a naturally occurring resource on earth, and having access to it in its purest form is vitally important for all living things, including humans and other animals, since the whole idea of existence would be inconceivable if water were absent from the equation. Because it has so many potential features, including high solubility power, for example, water is sometimes referred to as the universal solvent. The pollution of water supplies is now the most pressing issue facing the whole planet. This is the case for a variety of reasons, including poor sewage treatment, industrial wastes, marine dumping difficulties, radioactive waste material, some agricultural viewpoints, and so on. Safe and clean drinking water is necessary for the survival of humans and generally life on earth, as water quality directly impacts all living beings. Unavailability of potable surface water has made the ground water very important, and it is generally believed that the ground water is purer because of protective soil cover than surface water with no protection. Ground water is not only heavily used for daily purposes but also for agricultural use and providing water to industries all over the world. According to WHO, 80% of the diseases in the world are due to improper sanitation, polluted drinking water and unavailability of safe and clean water (WHO, 2019).

Over the past decades, one of the major environmental interests of many researchers around the world has been the water resources getting contaminated with various toxic compounds. It has been observed during the near past that quality of ground water has been deteriorating and getting heavily polluted due to chemical, physical, and biological conditions (Singh *et al*., 2017) [6]. Heavy metals are one of the major important water pollutants. The drastic use of heavy metals in industry have resulted in an increase in the presence of these metallic substances in natural water sources (Sandeep *et al*., 2019) [5]. Wastewater usually contains risky heavy metals; however it also contains helpful nutrients, which bring both favorable circumstances and difficulties for the cultivating community and general public health. It's apparent from the studies of different examiners, that modern industrial effluents are found to have risky metals in concentration above the admissible range of dangerous metals are now accessible to the human in the form of food chain is the most disturbing issue across the globe. Wastewater irrigation is a typical practice all over the world in numerous countries including Pakistan, wastewater is being utilized due to the deficiency of water for irrigation (Rehman *et al*., 2015) [3].

The discharge of heavy metals into the environment, which can come from a variety of natural and man-made sources, raises the probability that humans will be exposed to dangers of this kind. Sludge, as well as industrial and municipal and industrial effluents, as well as air pollution and solid waste disposal, are all examples of the different man-made sources. In general, the production of agricultural goods has various challenges as a result of potentially hazardous heavy metals that are introduced through the irrigation of wastewater. The practice of continuously irrigating major crops, vegetables, and fodder with wastewater contributes to the heavy metal concentrations and other salts in soil, and it is a possible source of phytotoxicity (Rehman *et al*., 2015) [3]. A high concentration of heavy metals in the soil has a detrimental effect on the growth of plants. There have been reports of numerous changes in plants' metabolic activities, including a slowdown in root growth, photosynthesis, and others (Rizwan *et al*., 2016) [4]

Traditional sorbents can remove heavy metal ions from wastewater, but their low sorption capacities and efficiencies severely limit their utilization. Because of its developed porosity and huge surface area, activated carbon is the most effective adsorbent among these classic adsorbents. However, because of its small weight, activated carbon has a long settling period, limiting its usage in water treatment operations. Nanoscale materials have the ability to alleviate numerous water quality issues. For water purification, a variety of nanoscale materials such as metal nanoparticles, zeolites, carbonaceous nanomaterials, and dendrimers are being used. These functional nanoscale materials exhibit a variety of physicochemical features and serve as reactive media for water purification (Soni *et al*., 2020). Nanoparticles have a substantially larger surface area, which makes them appealing sorbents. Nano adsorbents, particularly metallic nanoparticles, have proven to be effective water treatment agents. Iron and iron-containing nanomaterials and nano adsorbents, such as zero-valiant iron nanoparticles (nZVI), Fe2O3, and Fe3O4, are widely used in environmental remediation, notably for water decontamination. (Pasinszki, & Krebsz 2020) [2]

Experimental

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Collection of Raw Materials

Research work was carried out at the Department of Food Technology, PMAS Arid Agriculture University Rawalpindi. The watermelon and melon peels were collected from the fruit and vegetable market and washed with distilled water to remove dust particles, microbes or other foreign contaminants.

Pretreatment of Raw Material

Collected sample were treated with 10% ferric chloride hexa hydrate (BDH) solution in ethanol (BDH) for 24 hours at room temperature (Gong *et al*., 2012) [1].

Preparation of Iron Oxide Nanoparticles

For the preparation of iron oxide nanoparticles, the waste of watermelon and melon were taken.40gm of peel is added into de ionized water for extract preparation. In a volume ratio of 2:3, a solution containing 0.1 M ferric chloride was added to the peel extract. The addition of 1.0 M NaOH caused a shift in the pH of the solution, from 3 to 6. (Shahwan *et al*., 2011). The synthesis of iron nanoparticle was then performed. Plant extract was gradually added in solutions and boiled until the solutions color changed. The emergence of colour precipitates was interpreted as a sign of the creation of green Fe nanoparticles, depending on the extract. The solution was then added in falcon tubes 50ml and centrifuged at 7000 rpm for 20 mins. Pellets were collected and supernants were discarded. The Pellets were centrifuged thrice for removal of extra salt and plant extract. The iron nanoparticles were kept in an airtight dry container for further characterization and use as describe by Gong *et al*., (2012) [1].

Application of iron nanoparticles

He treatment of wastewater with chosen heavy metals was aided by the application of nanoparticles produced by plants. Experiments were carried out in order to determine the degree of reactivity shown by the metallic nanoparticles by adding them in various concentrations ranging from 0.1g/L – 1.25g/L at neutral pH while concentration of heavy metals in solution was constant at 5 mg/L. Removal (%) of arsenic, cadmium, chromium, copper, nickel, and lead, was measured for both adsorbents using standard method (Saif *et al*., 2019).

Result and Discussion

Application of iron oxide nanoparticles for heavy metals removal

Plant synthesized nanoparticles were applied for removal of arsenic, copper, cadmium, Nickle, lead. To evaluate the reactivity of the metallic nanoparticles, experiments were conducted. Removal (%) of Heavy Metals was measured for each metal adsorbent. The purpose was to be removed the heavy metals from wastewater

Iron Oxide (Fe_2O_3) nanoparticles for arsenic removal

The elimination of arsenic by nanoparticles of ferric oxide (Fe2O3) is seen in the figure. There was a considerable impact made by the adsorbent dosage on arsenic removal when the starting arsenic content was 5 mg/L, and the pH was neutral. On the other hand, the efficiency of Melon treated Fe2O3 nanoparticles was astonishingly great. Melon mediated Fe2O3 nanoparticles were able to remove 52% to 80% of arsenic with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, whereas *Watermelon* mediated Fe_2O_3 nanoparticles were able to remove 35% to 68% of Arsenic with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, *Melon* Fe_2O_3 nanoparticles were found to be most reactive.

Table 1: Analysis of variance for arsenic removal

Source	DF	SS	MS	F	P
Treatment	1	1254.4	1254.4	22.8	0.0004
Error	13	716.3	55.1		
Total	14	1970.7			

Grand Mean 54.200CV 13.70

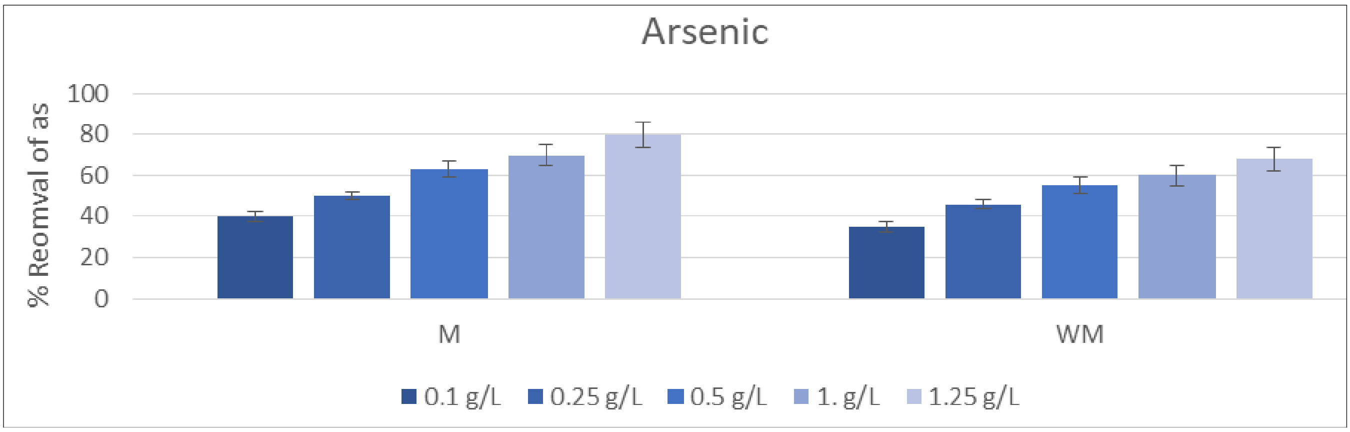

Fig 1: Graphical representation of influence of adsorbent dose on arsenic removal

Iron oxide (Fe_2O_3) nanoparticles for Cadmium removal

The elimination of cadmium by nanoparticles of ferric oxide (Fe2O3) is seen in the figure. There was a considerable impact made by the adsorbent dosage on cadmium removal when the starting arsenic content was 5 mg/L, and the pH was neutral. On the other hand, the efficiency of Melon treated Fe2O3 nanoparticles was astonishingly great. Melon mediated Fe2O3 nanoparticles were able to remove 15 % to 55% of Cadmium with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, whereas watermelon-mediated Fe2O3 nanoparticles were able to remove 13 to 51 percent of Cadmium with an increase in adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH. Melon Fe2O3 nanoparticles were discovered to be the most reactive,

Table 2: Analysis of variance for cadmium removal

Source	DF	SS	MS	F	P
Treatment	1	1876.90	1876.90	25.3	0.0002
Error	13	963.80	74.14		
Total	14	2840.70			

Grand Mean 32.200 CV 18.83

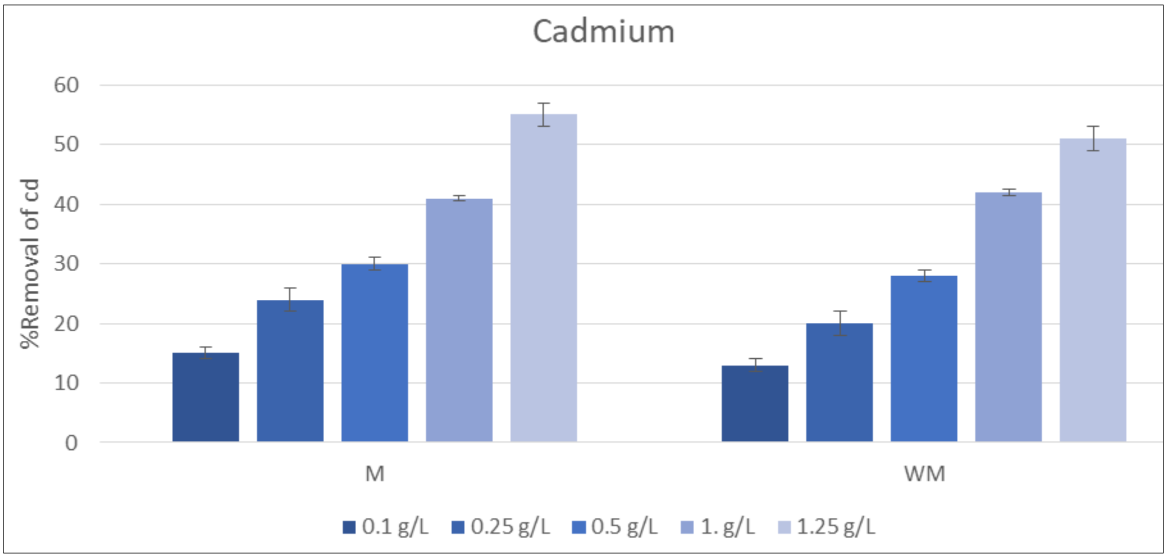

Fig 2: Graphical representation of influence of adsorbent dose on cadmium removal

Iron oxide (Fe_2O_3) nanoparticles for Lead removal

The elimination of lead by nanoparticles of ferric oxide (Fe2O3) is seen in the figure. There was a considerable impact made by the adsorbent dosage on lead removal when the starting arsenic content was 5 mg/L, and the pH was neutral. On the other hand, the efficiency of Melon treated Fe2O3 nanoparticles was astonishingly great. Melon mediated Fe2O3 nanoparticles were able to remove 21% to 70% of Lead with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, whereas *Watermelon mediated* Fe_2O_3 nanoparticles were able to remove 14% to 60% of Lead with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, *Melon* Fe_2O_3 nanoparticles were found to be most reactive.

Table 2: Analysis of variance for lead removal

Source	DF		SS	MS	F	P
Treatment	1		0.35666	0.05095	24.3	0.0000
Error	13		0.03360	0.00210		
Total	14		0.39026			

Grand Mean 34.800 CV 25.99

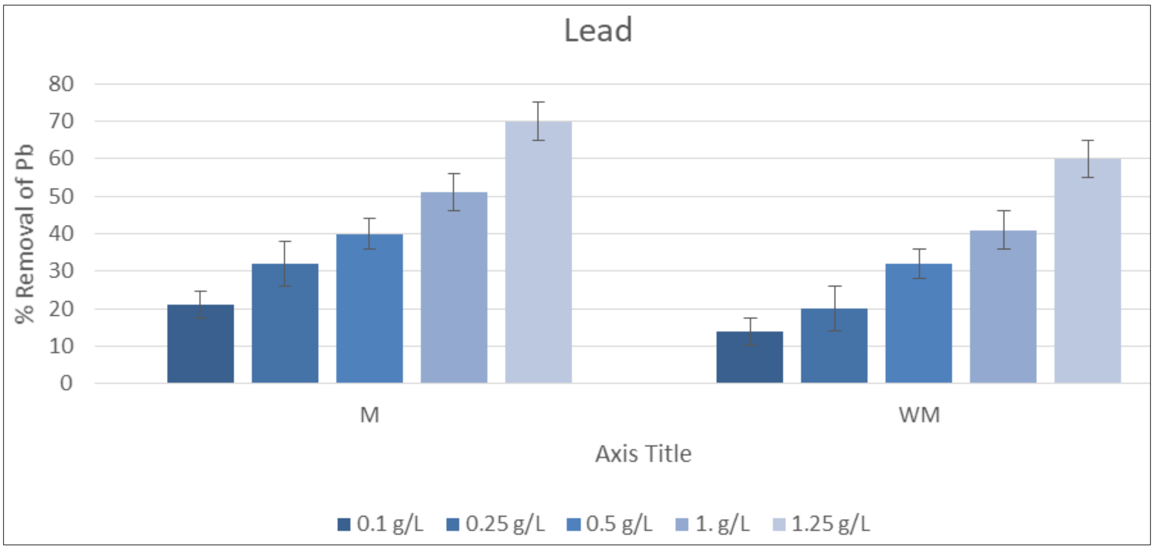

Fig 3: Graphical representation of influence of adsorbent dose on lead removal

Iron Oxide (Fe_2O_3) nanoparticles for Nickel removal

The elimination of nickel by nanoparticles of ferric oxide (Fe2O3) is seen in the figure. There was a considerable impact made by the adsorbent dosage on nickel removal when the starting arsenic content was 5 mg/L, and the pH was neutral. On the other hand, the efficiency of Melon treated Fe2O3 nanoparticles was astonishingly great. Melon mediated Fe2O3 nanoparticles were able to remove 17 percent to 64 percent of nickel with an increase of adsorbent dose from 0.1 g/L to 1.25 g/L at neutral pH, whereas watermelon mediated Fe2O3 nanoparticles were only able to remove 15 percent to 56 percent of nickel with the same increase in adsorbent dose

Table 4: Analysis of variance for nickel removal

Source	DF	SS	MS	F	P
Treatment	7	2.64660	0.37809	180	0.0000
Error	16	0.03360	0.00210		
Total	23	2.68020			

Grand Mean 36.600 CV 22.69

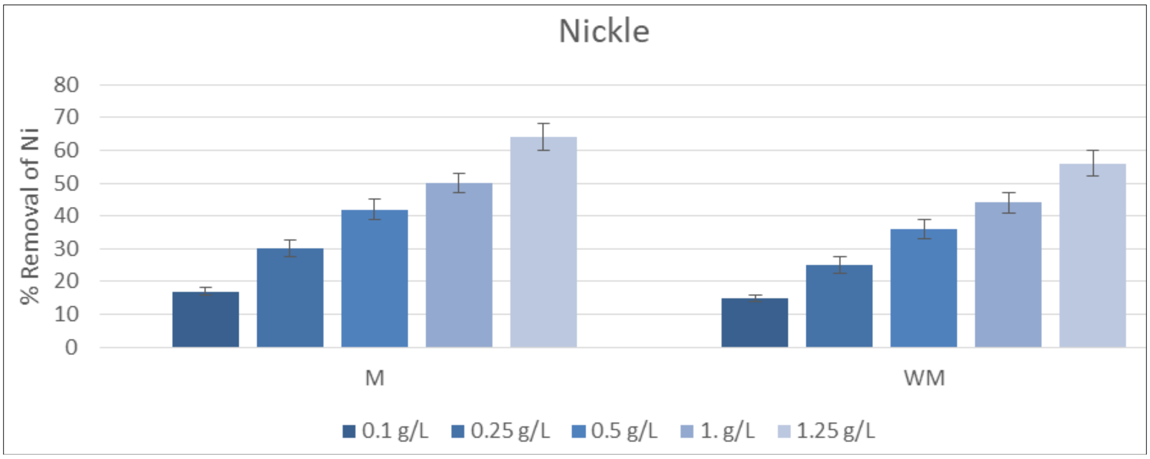

Fig Error! No text of specified style in document.**4:** Graphical representation of influence of adsorbent dose on nickel removal

Conclusion

Based on the data, it was determined that the adsorbent that was generated from waste watermelon and melon might have significant adsorption capabilities, and as a result, it has the potential to be utilized as an effective adsorbent for the removal of heavy metals. In conclusion, the findings of the study indicate that the wastewater in the area under investigation poses a chronic health risk. However, because some of the selected heavy metals exceeded their maximum allowable concentrations, it is recommended that the water from contaminated sites not be used for drinking without first undergoing treatment, and it is possible that the government of Pakistan will provide alternative sources of drinking water to the areas

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