Determination of potential use of chitosan for the removal of Pb, Fe and Mn in the water samples collected from different areas of Sri Lanka

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Introduction

Water contamination is one of the major concerns in the world. From the beginning of the 21st century, the drinking water sources in the main agricultural regions under reservoir based irrigation of Sri Lanka have been polluted from heavy metals in considerable amounts and exposure to heavy metals can cause a number of health problems, ranging from nausea and stomach discomfort to development of cancers and kidney diseases (Bandara *et al.,*2008). Although a wide range of physical and chemical processes are available for the removal of heavy metals from natural water bodies, most of these methods are not practicable to developing country like Sri Lanka as they are extremely expensive. In recent years, biosorption has been recognized as an effective method of removal of heavy metal contaminants in surface water as low cost bio-adsorbents are readily available, environmentally friendly, and biodegradable**.** The bioadsorbent chitosan; deacetylated product of chitin (Gamage *et al.,*2007) has been used as a bioadsorbent for the removal of toxic/heavy metals from waste water. Depending on the pH of the medium the interaction of metals with chitosan are possibly dominated by adsorption, ion-exchange and chelation. Chitosan has been used to remove heavy metals mainly from industrial wastewater and as a non-toxic flocculent in the treatment of organic polluted wastewater (Shanmugapriya *et al.,* 2011); but little attempt has been made to understand the ability of chitosan to uptake heavy metals in polluted drinking water containing trace amounts (ppb levels) of heavy metals (De Silva *et al.,*2014).

The current study focuses on potential of using chitosan as a low cost, environmentally friendly biosorbent for purification of drinking water contaminated by the low levels of heavy metal pollutants; Pb, Fe and Mn.

Methodology

Drinking water samples were collected from different areas of the country including Anuradhapura, Nikkawewa, Vavuniya, Trincomalee, Badulla and Kantale. First the basic parameters such as colour, pH and total hardness of the collected water samples were measured and recorded. Then the initial metal ion concentration of Pb, Fe and Mn of acid digested water samples were measured using AAS.

Next, all the water samples with initial metal ion concentrations above the permissible limits for drinking water defined by the World Health Organization (WHO) were treated with chitosan as follows. A finely crushed chitosan (0.0250 g) was taken separately into clean dry polypropylene containers. A volume (50.00 mL) of digested water sample was introduced into polypropylene container having chitosan sample. pH of the sample was adjusted to pH 7 using NaOH (0.1 M) and the sample container was stirred at room temperature (29.0 ± 0.5 C) for 2 hours. Control sample was prepared simultaneously with chitosan (0.0250 g) and deionized water (50.00 mL) and pH was adjusted to pH 7. Control sample was also stirred at room temperature (29.0 ± 0.5 C) for 2 hours. After 2 hours stirring period, both sample and control were filtered using filter papers. Filtrates of sample and control were analyzed by AAS to determine the amount of Pb, Fe, and Mn remaining in the solutions after treatment with chitosan. The procedure was carried out in duplicate for each digested drinking water sample.

Result and Discussion

The pH values of the collected water samples range from 6.53 – 7.31 which were in the range of accepted pH value range (6.5 – 8.5) for drinking water defined by WHO. But hardness in some of the collected water samples had exceeded 250 ppm, the maximum permissible level defined by the Sri Lanka Standards Institution (SLSI) for the drinking water.

The Initial metal concentrations in collected water samples, metal concentrations after treatment with chitosan, and percentage metal removal (%) of Pb Fe and Mn are shown in table 1, table 2 and table 3 respectively. The maximum permissible levels for drinking water given by WHO for corresponding metals are shown in table 4.

Table 1: Concentration of Pb in water samples - before and after treatment with chitosan.

Sample No	Water Sample	Concentration of Pb (µg/L)		% removal
		Before treatment	After treatment with chitosan	
01	Vavuniya Tank 01	19.50 (±0.13)	6.26 (±0.12)	67.89
02	Vavuniya Tank 02	22.12 (±0.06)	7.61 (±0.04)	65.59
03	Vavuniya Tank 03	14.62 (±0.24)	5.70 (±0.08)	61.01
04	Vavuniya Tank 04	17.15 (±0.11)	6.92 (±0.22)	59.65
05	Vavuniya Well	20.62 (±0.04)	8.34 (±0.14)	59.55
06	Paththawewa Tank	15.72 (±0.07)	8.76 (±0.03)	44.27
07	Wepannkulam Tank	12.14 (±0.03)	7.72 (±0.31)	36.41
08	Anuradhapura Well 1	18.72 (±0.16)	9.76 (±0.14)	47.86
09	Nikkawewa Well	16.41 (±0.02)	7.36 (±0.20)	55.15
10	Kantala Tank	13.25 (±0.12)	5.27 (±0.03)	60.23

Table 2: Concentration of Fe in water samples - before and after treatment with chitosan.

Sample No	Water Sample	Concentration of Fe (µg/L)		% removal
		Before treatment	After treatment with chitosan	
01	Paththawewa Tank	385.00 (±0.05)	115.30 (±0.03)	70.05
02	Nikawewa Tank	879.00 (±0.04)	270.50 (±0.12)	69.23

Table 3: Concentration of Mn in water samples - before and after treatment with chitosan.

Sample No	Water Sample	Concentration of Mn (µg/L)		% removal
		Before treatment	After treatment with chitosan	
01	Paththawewa Tank	1003.00 (±0.13)	270.00 (±0.08)	73.08
02	Wepannkulam Tank	827.00 (±0.04)	255.50 (±0.23)	69.11

Table 4: Maximum permissible levels given by WHO for Pb, Fe and Mn.

Metal	Maximum permissible level/ □ g/L
Lead (Pb)	10
Iron (Fe)	300
Manganese (Mn)	400

According to the results, all the water samples with higher levels of Pb, Fe and Mn concentrations were successfully reduced into the permissible range defined by WHO by treating with biopolymer chitosan.

Conclusion

Interestingly, all the water samples with initial metal ion concentrations above the permissible limits were successfully reduced into the permissible range defined by WHO by treating with chitosan, further proved that chitosan might be a good candidate which can be used to remove heavy metals from polluted drinking water. The average percentage removal of lead, iron and manganese by chitosan is 55.77% 69.65% .and 69.60% respectively.

References

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