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Marine sponge Demospangiae in novel adsorption of arsenic in aqua environment

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Abstract

The over-population increase and the industrialization of societies, especially from the second half of the current century, have created new environmental problems. High level of pollutants from industrial effluents, urban sewage, and watering of agricultural land has contributed to the collapse of the biological balance of waterlogged aquifers and has caused many problems for the health of the environment and communities. The limitation of water resources, on the one hand, and the increase of toxic contaminants in surface and groundwater, requires finding different and acceptable environmental solutions to eliminate such pollutants. One of the main sources of environment pollution is the industrial wastewater which contains heavy metals and can be found in many industries. In this study the removal of pollutants by using nanoparticle biofilters were measured. In this issue a kind of species of Demospongiae sponge at 6 meters depth in the Persian Gulf in Assaluyeh, Bushehr Province, Haliclonatoxia, was identified. The concentration effect of the form also increased with increasing concentration of adsorption capacity. The size of the absorbent particle size increased by absorbing capacity, according to the shape in the size of 230 mesh. As it can be seen, the results of the capacity of Arsenic adsorption by sponge in this study have more capacity than other adsorbents. It was determined that the concentration of arsenic adsorption in Haliclonatoxia sponge was 4.35 ppm. This is the highest adsorption capacity of Arsenic in comparison with reported articles for selective separation of Arsenic. It was higher than other identified biofilters.

Keywords: Demospongiae sponges; Organic and mineral pollutants; Marine environments; Persian Gulf.

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1. Introduction

Water has a broad impact on all aspects of human life including but not limited to health, food, energy, and economy, in addition to the environmental, economic, and social impacts of poor water supply and sanitation. There is limited possibility of an increase in the supply of fresh water due to competing demands of increasing populations throughout the world; also, water-related problems are expected to increase further due to climate changes and due to population growth over the next two decades (Mara, 2003; Johnson *et al.*, 2008).

Industrial effluents loaded with heavy metals are the cause of serious hazards to human and other forms of life. However, conventional methods such as precipitation, ion exchange, electro dialysis, etc. used for the removal of heavy metals from wastewater, are often cost prohibitive having inadequate efficiencies at low metal ion concentration. Conventional wastewater treatment methods are not sufficiently effective in removing organic and chemical pollutants. There is demand for the use additional processes like precipitation and chemical coagulation, flocculation, desorption, neutralization, and reverse osmosis for more thorough purification. Unfortunately, these methods, in many cases, are not sufficiently effective in eliminating pollution, or the economical side of carrying out prevents them from being used on a larger scale wastewater treatment (Bartolomeu, 2018).

Bioabsorption can be considered as an alternative technology which has been proved as more efficient and economical for the removal of heavy metals from the industrial wastewater (Mazaheri-Tehrani, 2012). In these studies active carbon resulting from burning straw has been used in order to remove cadmium. Recently, numerous studies reported that the nanosorbent materials have a great and quite promising effect on water and wastewater treatment such as carbon tube, polymeric, zeolites, metal and metal oxides nanosorbents (El-sayed, 2020). Adsorbents have combined with magnetic material and coated on optical fibers improving their usability in water treatment (Bandara been incorporated in membrane technologies, and photocatalysts (Fanourakis *et al.*, 2020). In another study, based on the properties of nano-carbon materials, adsorptive elimination mechanisms for antibiotics, dyes, heavy metals, pesticides, oils, phenolic and volatile organic compounds and gas pollutants are highlighted. The advantageous characteristics of nano-carbon materials assigned to their unique adsorptive removal of common hazardous substances will be pointed out (Sabzehmeidani *et al.*, 2021).The adsorptive efficiency of MWCNTs-KIAgNPs , a nano adsorbent for the removal of Cr(VI), Ni(II), Fe(II), Cd(II) and physico-chemical parameters like pH, TDS, COD, BOD, nitrates, sulphates, chlorides and phosphates from chemical industrial wastewater was examined in both batch and fixed bed systems (Egbosiuba *et al.,* 2021). Novel method is reported to fabricate nano-sponge materials by mixing hydrophobic porous hydrocarbon nanoparticles (NPs) and hydrophilic TiO_2 NPs. The nano-sponge can selectively and effectively absorb oil from water due to their oleophilicity of hydrocarbon NPs. On the other hand, hydrophilic and underwater oleophobic nature due to the TiO_2 NPs in the nano-sponge extracts the absorbed oil into water in response to UV irradiation. By mixing the hydrocarbon NPs and UV-responsive hydrophilic TiO_2 NPs, one can control the wettability of the nano-sponge for oil and water. The nano-sponge/ porous polydimethylsiloxane (NS/p-PDMS) could be fabricated by decorating the nano-sponge within the porous structure (Jung *et al*., 2015).Extensive studies also have been done on some adsorbents like chitosan Nano-particles and modified MCM-41 Nano- porous in the world (Ekhlasi *et al*., 2011; Heidari *et al*., 2009). In this research a kind of sponge has been used as an adsorbent for Arsenic in water. In addition, the effect of influencing factors in adsorption process has been studied and examined. Sea sponges have been used as a source of pharmaceuticals (Bhimba *et al.,* 2013; Lunder *et al*., 2012; Senthilkumar *et al*., 2013), and as a biological index in oil materials and its derivatives (Batista *et al.,* 2013). Sponges are among the simplest multi-cellular organisms which all of them are different from each other and don't have fixed physical shape and they exist in different shapes. Their body is covered with pores. All sponges reside in water especially in sea water. There is no coordination between cells. All sponges can also arise again from some separate cells; they have high rehabilitative power. Sponges are classified in three groups of Calcarea, Hexacttinellida and Demospongiae. The purpose of this study is to assess the efficiency of Demospongiaesponge, Haliclonatoxia in adsorption Arsenic as well as the effect of different parameters in adsorption capacity and percentage of this semi metal, which can be a suitable base for sponge's efficiency as a natural and biological adsorbent in adsorption process of metal ions.

2. Materials and methods

Materials: for providing required standards and chemical solutions, salts of Merck Company with analytical grade have been used. As $(No_3)_3$, $HClO_4$, HNO_3, and deionized water.

Devices: atomic absorption spectroscopy device model no. AA240 made by VARIAN Company of Australia with air flame- acetylene and halo-cathode lamp; Scanning Electron microscope model no. S4160 made by HITACHI Company; Quantachrome device model Nova2000 made by USA, pH-meter model no. GP353 made by EDT Company with glassy electrode made by METROHM Company, EC-meter pencil portable model made by England JENWAY company; Shaker model no. CB631 (Incubator) made by Iranian FATER ELECTRONIC Company; digital scale model no. AJ100 made by METTLER Company, mill moulinex model GENIUS 2000, sieve with 70, 120 and 230-mesh grading and other glassy supplies of laboratory.

2.1. Preparing of adsorbent

This sponge is collected from Asalouyeh, Boushehr, and Persian Gulf. Sponge sampling was done through diving and investigation in 5-6 meters depth near Asalouyeh, the shore of the Persian Gulf in 270 km SE of the provincial capital of Bushehr, between geographic coordinates 52 degree, 35 min. and 59.99s eastern length from Prime meridian, and 27 degree, 29min. and 59.99s of northern width in April 2018 (Iranian date: Ordibehesht month of 1397). Sponges have been separated from the floor to which they were attached and then sample was put in a sack. From sample, a small piece was cut and, in order to be identified, has been put in containers containing ethanol (Figure 1).

In order to do the experiments, the interested sponge was divided into 10- gram pieces

Figure 1. Demospongiae sponge in seabed from Asalouyeh, *Asalouyeh.*

and after several times complete washing by distilled water, was dried in sun light in order to remove adsorbed ion of sea water. Sponges in two ways of pieces and powdered with 70, 120 and 230- mesh grading were used in order to remove aforementioned ion.
In this research that is undertaken for the first time, by using a sponge (Figure 2) in removing Arsenic from aquatic environments by the following specification:

2.2. Methodology

The 0.1gram weight of dried sponge was taken and in two forms of small pieces of sponge and powdered sponge with 70, 120 and 230 mesh grading was put in a baker and then 50 ml volume of solution containing Arsenic was added. This solution containing Arsenic solution has been studied in two ways of shaker and non-shaker for 1, 6, and 12hours. Then, the solution under study was filtered and the amount of Arsenic in solutions under the sieve has been measured by atomic absorption spectroscopy device with flame. All the performed experiments in this study were repeated 2 to 3 times according to the existent conditions medium. In order to prevent any error, all the containers being used were washed with acid and finally were washed with deionized distilled water. All the experiments were performed in room temperature.

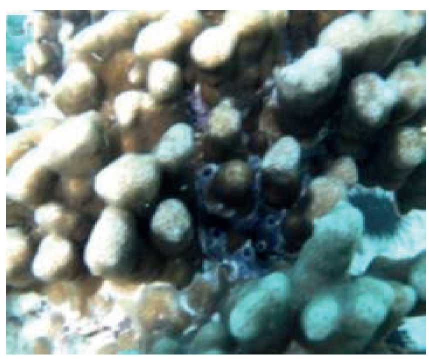

Figure 2; Demospomgiae Sponge (Haliclonatoxia)
Class:*Demospongiae*
Species:*Haliclonatoxia*

2.3. Determination of adsorbent nano-particles structure

In order to find the kinetic reaction, a certain amount of under study adsorbent, , has been put in contact with certain concentration of Arsenic solution in different time duration; and the percentage and capacity of adsorption of Arsenic by adsorbent was evaluated.

2.3.1 Effect of particle size

In order to study the effect of sponge particles size on the efficiency of adsorbent, at first stage the interested washed and dried sponge was ground and passed through sieves with 70, 120 and 230 mesh grading. 0.1 gram70, 120 and 230 mesh sponge powder was added to 50 ml solution containing Arsenic. Then, under study solutions were filtered in pH of 4 to 5 and the amount of Arsenic in solutions under the sieve has been measured by: atomic absorption spectroscopy device with flame.

2.3.2 Effect of shaker

In order to examine the effect of shaker on adsorption Arsenic ion, Erlenmeyer containing 0.1g sponge and mentioned ionic solution with various concentration of 10, 25, 50, 100, 200, 250, and 300 mg/Liter related to Arsenic ion were put on shaker device for one hour with 150 in rotation. Then, the solutions were filtered and the amount of Arsenic ion in solutions under the sieve has been measured by atomic absorption.

To calculate interested adsorption capacity and percentage, we separated 0.1g sponge and added various concentrations of metal ion in different conditions. Then, the solution was filtered and adsorption was measured. In order to calculate adsorption capacity the following equation is used (Piccin *et al.*, 2011; Edet and Ifelebuegu, 2020):

$$e = [(C_o - C_i)\ v]/m \quad (1)$$

where, e is the amount of adsorbed metal ion in terms of mass adsorbent mg/g, C_o and C_i are initial concentration of metal ion and secondary concentration of metal ion in mg/lit, V is the volume of the solution in terms of liter, and m the mass adsorbent in terms of gram. The percentage of absorption is calculated by the Equation (2):

$$\%p = [C_o - C_i)/C_o]*100 \quad (2)$$

where, %p is percentage of absorption.

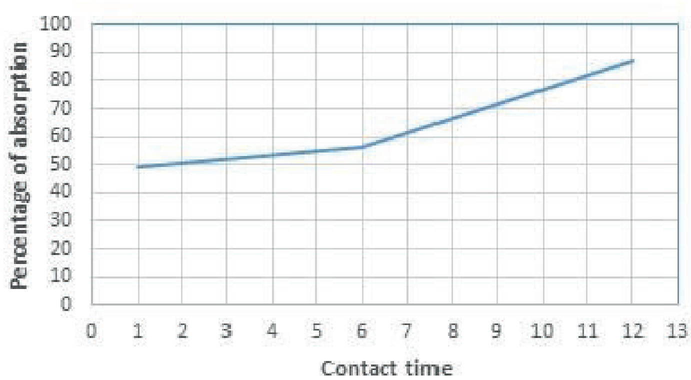

Figure 3. The effect of contact time on adsorption capacity of Arsenic (adsorbent: sponge pieces)

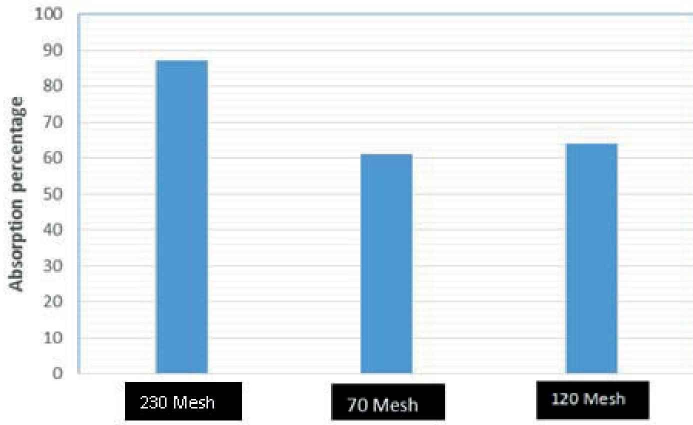

Figure 4. The Effect of particle size in absorption percentage of Arsenic (adsorbent: 70, 120, and 230 mesh sponge)

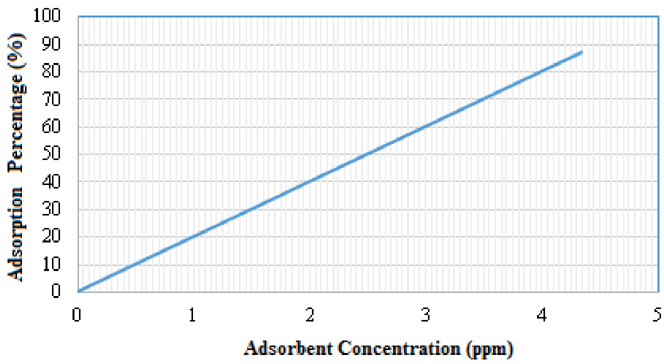

Figure 5. The Effect of concentration on adsorption capacity of Arsenic

3. Results

3.1. Contact time

By increasing the contact time, due to rising the opportunity of clashing Arsenic and adsorbent particles, the adsorption level will increase. contact time of adsorbent with Arsenic has been considered for 1, 6, and 12 hours, of which the highest adsorption capacity belongs to high level concentration after 12 hours was 4.35 ppm (Figure 3).

3.2. The size of adsorbent particles

Increasing the adsorbent area will raise the amount of accessible positions and leads to higher level of adsorbent efficiency for removing metal ions. Through comparing the adsorbed level of Arsenic ion by powdered sponge it is found that the under- study adsorbent has more ability for adsorbing Arsenic ion with increasing the adsorbent area and the highest adsorption capacity belongs to 250 ppm concentration after passing 12hours with powdered sponge of 230 meshes grading that is 4.35 mg/L (Figures 4 and 5).

3.3. Effect of shaker

As shown in Figure 6, the capacity of absorption was increased with shaker to the highest level of absorption caught by powder form of Demospongiae sponge Heliconatoxia of 230 mesh size with shaker.

4. Discussion

One of the important factors in adsorption level is the increase of contact time with adsorbent and moreover the results from the research have shown that adsorption level also depends on particle size. According to the results (Figures 2) by increasing the contact time, due to rising the opportunity and chance of clashing metal ions and adsorbent particles, the adsorption level will increase and also increasing the surface area will rise the amount of accessible positions and leads to higher level of adsorbent efficiency for removing or substituting metal ions. Experiments show that the amount of Arsenic ion's adsorption capacity by small piece of sponge was 1.52 mg/g and by powdered sponge was 4.35 mg/g.

The reason can be attributed several factors such as chemical characteristic of adsorbent, physical structure of adsorbent, porosity, surface area, particle size as well as chemical nature of Arsenic, molecular weight and the size of ionic radius (Figures 3) (Hosseini, 2017). As it is shown in figures (Figure 6), shaker can have considerable effect on absorbance percentage, since during shaker, due to rising the opportunity and chance of clashing metal ions with adsorbent particles, finally the adsorption level will increase. This adsorption rising has taken place for Arsenic up to 250 ppm concentration, that after which in higher concentration more than 250 ppm a falling trend has been observed which can be resulted from ions' non-adsorption phase (Figure 6). But the highest adsorption capacity belongs to Arsenic of 250 ppm concentration after passing12 hours with shaker next to powdered sponge of 230- mesh grading that is 4.35 mg/g (Figures 2 to 6). The rising adsorption can be explained by this reason that increasing more spaces in adsorbent's surface (230 meshes), has provided more effective area for adsorbing lead ions.

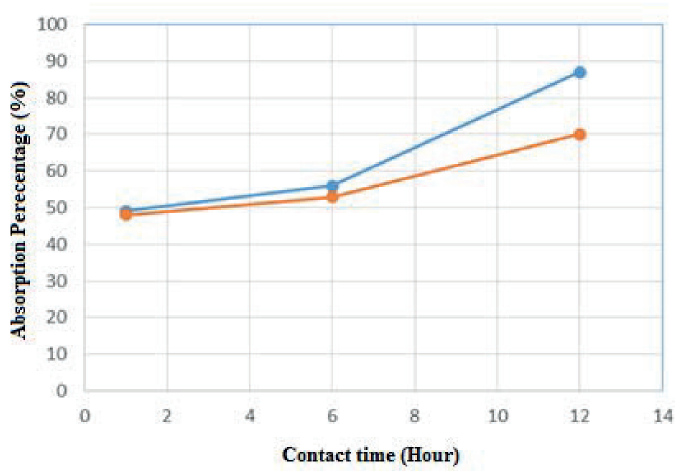

Figure 6. The effect of shaker on the adsorption capacity of Arsenic (with powdered sponge)

According to the performed examinations by researchers on general applications of this type of sponge, here we tried to obtain the adsorb ability of Arsenic, ions by this sponge to be able to use it as a practical tool in production of bio-filters used in water filtration. Experiments showed that this kind of sponge is suitable for removing Arsenic. Hence, with regard to the obtained results it can be said that this adsorbent shows the highest level of adsorption for Arsenic ion. Therefore, one can assess a practice to make adsorption columns or adsorption filters out of this type of sponge.

References

Bartolomeu, M., Neves, M.G.P.M.S., Faustino, M.A.F., and Almeida, A. 2018. Wastewater chemical contaminants: Remediation by advanced oxidation processes. Photochemical & Photobiological Sciences, 17: 1573–1594.

Batista, D., Tellini, K., Nudi, A. H., Massone, T. P., de L. Scofield, A., and de L. R. Wagener, A. 2013. Marine sponges as bioindicators of oil and combustion derived PAH in coastal waters Marine Environmental Research, 92:234-244.

Bhimba, V., Vinod, V., and Beulah, C. 2013. Marine Sponge Sigmadociapumila a potential supply for drug findings Journal of Pharmacy Research, 6(4): 401-403.

Edet, U.A., and Ifelebuegu, A.O. 2020. Kinetics, isotherms, and thermodynamic modeling of the adsorption of phosphates from model wastewater using recycled brick waste. Processes, 8(6): 665-670.

Egbosiuba, T.C., Abdulkareem, A.S., Kovo, A.S., Afolabi, E.A., Tijani, J.O., and *et al*. 2021. Adsorption of Cr (VI), Ni (II), Fe (II) and Cd (II) ions by KIAgNPs decorated MWCNTs in a batch and fixed bed process. *Scientific Reports*, *11*(1), pp.1-20.

Ekhlasi, L., Younesi, H., Mehraban, Z., and Bahramifar, N. 2011. Synthesis and Application of Chitosan of Lead Ions from Aqueous Solutions. Journal ofWater and Wastewater, 1: 10-18.

El-sayed, M E.A.2020.Nanoadsorbents for water and wastewater remediation, Science of The Total Environment, https://doi.org/10.1016/j.scitotenv.2020.139903

Fanourakis, S.K., Peña-Bahamonde, J., and Bandara, P.C. 2020. Nano-based adsorbent and photocatalyst use for pharmaceutical contaminant removal during indirect potable water reuse. npj Clean Water 3, 1. https://doi.org/10.1038/s41545-019-0048-8

Heidari, A., Younesi, H., and Mehraban, Z. 2009. Removal of Cd (II), Ni (II) and Pb (II) Ions in an Aqueous Solution by Chemically Modified Nano porous MCM-41. J. Water and Wastewater, 1: 25-32.

Hosseini, E.K., Ghafourian, H., and Rabbani, M. 2018. Selective Separation of Lead Ions Using New Nano-Adsorbent GH-92. International Journal of Computational and Theoretical Chemistry, 6(1):14-19.

Johnson, D. M., Hokanson, D R., Zhang Q., Zupinski, K.D, and Tang, J. 2008. Feasibility of water purification technology in rural areas of developing countries. Journal of Environmental Management, 88(3): 416–427.

Jung, M.C., Cho, S.H., Kim, S.H., Kim, H.Y., Lee, H.J., and et al. 2015. UV-responsive nano-sponge for oil absorption and desorption. Scientific reports, *5*(1): 1-12.

Lunder, M., Drevenšek, G., Hawlina, S., Sepčić, K., and Žiberna, L. 2012. Cardiovascular effects induced by polymeric 3-alkylpyridinium salts from the marine sponge RenierasaraiToxicon, 60(6): 1041-1048.

Mara, D.D. 2003.Water, sanitation and hygiene for the health of developing nations, Public Health, 117(6): 452–456.

Mazaheri-Tehrani, M. 2013. Removal of toxic heavy metals: natural products' as biosorbents. Feyz Journal of Kashan University of Medical Sciences, 16(7): 721- 722.

Piccin, J.S., Dotto, G.L., and Pinto, L.A.A. 2011. Adsorption isotherms and thermochemical data of FD&C Red n 40 binding by Chitosan. Brazilian Journal of Chemical Engineering, 28: 295-304.

Sabzehmeidani, M.M., Mahnaee, S., Ghaedi, M., Heidari, H., and Roy, V.A. 2021. Carbon based materials: a review of adsorbents for inorganic and organic compounds. Materials Advances, 2(2): 598-627.