World Wide Journal of Multidisciplinary Research and Development

WWJMRD 2018; 4(3): 151-156
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
UGC Approved Journal
Impact Factor MJIF: 4.25
E-ISSN: 2454-6615

Rania M. Nasser
Alexandria University, Institute of Graduate Studies and Research, Department of Environmental studies
Alexandria, Egypt

Ibrahem E. Omran
Alexandria University, Institute of Graduate Studies and Research, Department of Environmental studies
Alexandria, Egypt

Correspondence:
Rania M. Nasser
Alexandria University, Institute of Graduate Studies and Research, Department of Environmental studies
Alexandria, Egypt

A Study on Remediation of Some Heavy Metals in Mariout Lake

Rania M. Nasser, Ibrahem E. Omran

Abstract

Summary: Lake Mariout one of the major lakes in Egypt and forms the southern boundary of the city of Alexandria. It lies between Latitude31º 07' N and Longitude 29º 57'E along the Mediterranean coast of Egypt. It has an area of 60 km^2 and ranges in depth from 1 to3 m. it has been in existence for more than 6,000 years. It covered an area of approximately 700 km^2, extending more than 40 km southeast and 70 km southwest along the Mediterranean cost. The lake has gone over the years many changes to the extent that it became dry in several years. There is no any connection with the sea, but it was getting its water from River Nile

Nickel is a silvery white metal of the periodic table. It has a specific density of 8.90 g/cm^3; it is insoluble in water, soluble in dilute nitric acid and aqua regia, slightly soluble in hydrochloric and sulfuric acid. Nickel usually has an oxidation state of two.

Chromium atomic number 24, relative atomic mass 51.96 occurs in oxidation states from -2 to +6, but only the 0 (elemental), +2, +3 and +6 states are common.

Cadmium atomic number 48; relative atomic mass 112.40, Some cadmium compounds are practically insoluble in water, which can be changed to water-soluble salts in nature under the influence of oxygen and acids. Most of the cadmium found in mammals, birds, and fish is probably bound to protein molecules.

Keywords: Chromium, Cadmium, Nickel, remediation, Alfalafa, Bacillus subtilis, Lake Mariout.

Aim of the study

- Monitor the level of some heavy metals in sediments and water of Mariout Lake.
- Suggest a suitable remediation methodology of these heavy metals**.**
- Study a comparison between chemical methods and bioremediation methods for heavy metals treatment in water and sediments collected from Mariout Lake**.**

Material and methods

Samples

Table 1: Collected sample type and location.

Location No.	Longitude (N)	Latitude (E)	Type of sample
1	31° 07.702'	029° 53.245'	Water and sediment
2	31° 07.886'	029° 52.848'	Water and sediment
3	31° 09.038'	029° 52.455'	Water and sediment
4	31° 08.271'	029° 51.936'	Water and sediment
5	31° 08.452'	029° 51.576'	Water and sediment
6	31° 08.470'	029° 51.536'	Water and sediment
7	31° 08.446'	029° 51.509'	Water and sediment
8	31° 08.495'	029° 51.480'	Water and sediment
9	31° 08.477'	029° 51.480'	Water only
10	31° 08.529'	029° 51.391'	Water and sediment

Heavy metals stock preparation.

- Nickel stock solution consisted of (g/1 de-ionized water): Nickel Chloride (as Ni^{+2}) 110.4 g "$NiCl_2$", 1ml stock solution equal 50 mg Ni^{+2}

- Chromium stock solution consisted of (g/1 de-ionized water): Potassium chromate (as Cr^{+6}) 186.74 g "K_2CrO_4", 1ml stock solution equal 50 mg Cr^{+6}.
- Cadmium stock solution consisted of (g/1 de-ionized water): Cadmium Chloride (as Cd^{+2}) 81.54 g "$CdCl_2$", 1ml stock solution equal 50 mg Cd^{+2}.

Removal of heavy metals "Bactria"

Bacillus subtilis bacteria were activated by enrichment culture technique by inoculated to 50 ml sterile lurail broth media (L.B.) in 250 ml Earlmayer flasks and incubated for one day on rotary shaker incubator under aerobic conditions at 30 °C and 120 rpm. After activation by using Luria Bertani broth media (L.B.), Bacillus subtilis growth on salt medium (MSM) containing potassium chromate "K_2CrO_4" as hexavalent chromium, Nickel Chloride and Cadmium Chloride with different concentration and mixes of three metals.

The bacterial strains could not grow without a single carbon source. Therefore, through nutrient optimization process, 1.0% glucose was added in MSM-broth and as growth supportive substrates. Flasks were incubated for 6 days on rotary shaker incubator under aerobic conditions at 30 °C and 120 rpm

Removal of heavy metals "plant"

70 Alfalafa seeds (plant grow) were soaked in formaldehyde 3% for 10 min to reduce fungal contamination, washed 3 times with deionized water and put in the pots.

Pots provide with a photoperiod for 12 hr. at 1500 LUXES, pots covered with transparent plastic bags to avoid excessive desiccation and prevent air borne contamination, Each pot required 100 ± 10 ml of water to be saturated for first time and 50ml to irrigate every day. The first 7 days irrigated with deionized water without present of any heavy metals.

Analytical Techniques

Measuring nickel content "ASTM, 2009"

This test method is applicable in the range from 0.1 to 10 mg/L of nickel. The range may be extended upward by dilution of the sample by using atomic spectroscopy according to ASTM "D1886-94".

Measuring chromium content "ASTM, 2009"

The test method is applicable in the range from 0.01 to 50 mg/L chromium. The range may be extended by appropriate sample dilution by using phenyl di-carbazid and spectrophotometer or atomic spectroscopy according to ASTM "D1687-92".

Measuring cadmium content "ASTM, 2009"

This test method is applicable in the range from 0.5 to 20 mg/L of cadmium. The range may be extended to concentrations greater than 20 mg/L by dilution of the sample by using atomic spectroscopy according to ASTM "D3557-95".

Result

Table 2: Sediment analysis result (routine analysis)

Soil type	**Sandy loamy**		
Soil composition	Clay	Silt	Sand
	8%	35%	57%
pH	7.25		
Conductivity ms/cm	38.2		
Ca^{+2}mg"eqv"/l	47.5		
Mg^{+2}mg"eqv"/l	53.5		
Total hardness "CO_3^{-2} and HCO_3^{-1}"	2		
Cl^{-1}mg"eqv"/l	391.0		
Na^{+}mg"eqv"/l	510		
K^{+}mg"eqv"/l	143		

Table 3: Nickel, Chromium and Cadmium concentration in sediment (routine analysis)

Soil sample	Nickel	Chromium	Cadmium
1	65.2	41.3	Nil
2	23.61	Nil	Nil
3	116.05	97.9375	Nil
4	132.5525	17.77222	Nil
5	141.9125	182.6375	Nil
6	109.2875	138.3	Nil
7	34.5125	6.5375	Nil
8	123.4375	130.475	Nil
10	80.6875	85.025	Nil

Table 4: COD result for water sample (routine analysis)

Sample code	COD result	Sample code	COD result
1	1000	**2**	980
3	1050	**4**	1001
5	1059	**6**	940
7	1025	**8**	1068
9	1178	**10**	974

Table 5. BOD result for water sample (routine analysis)

Sample code	BOD result	Sample code	BOD result
1	760	**2**	800
3	624	**4**	752
5	742	**6**	781
7	820	**8**	819
9	804	**10**	800

Study of bacterial removal versus plant removal efficiency of Chromium, nickel and cadmium.

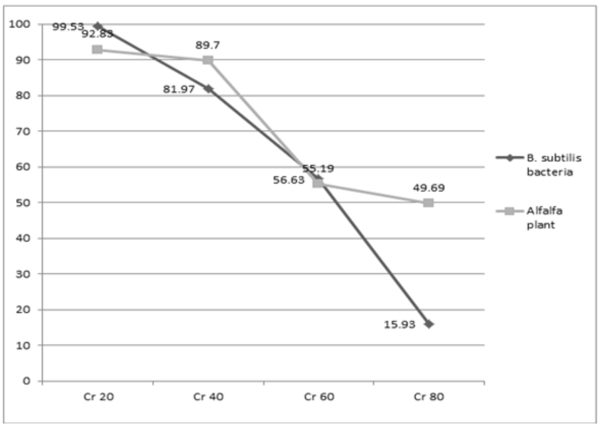

Fig. 1: Comparison between B. subtilis and Alfalfa plant in removal efficiency of chromium at different concentration.

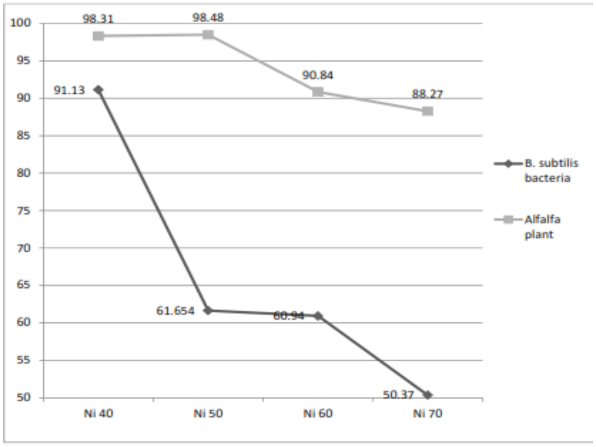

Fig. 2: Comparison between B. subtilis and Alfalfa plant in removal efficiency of nickel at different concentration.

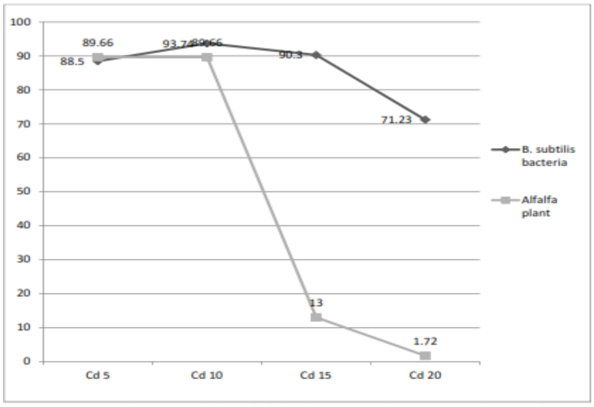

Fig. 3: Comparison between B. subtilis and Alfalfa plant in removal efficiency of cadmium at different concentration.

Study of different chromium, nickel and cadmium mix total removal efficiency

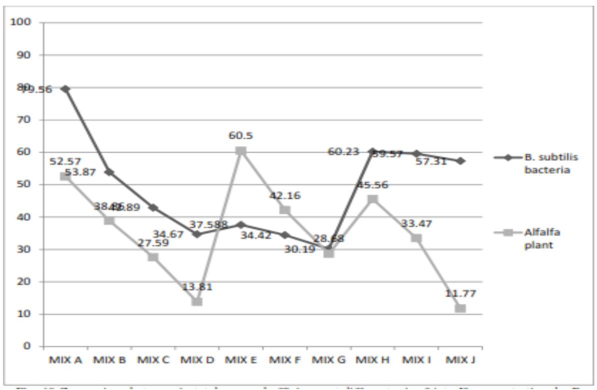

Fig. 4: Comparison between in total removal efficiency at different mixs "A to J" concentration, by B. subtilisbacteria and Alfalfa plant.

From the fig.4. the total removal efficiency was higher in B. subtilis bacteria more than Alfalfa plant and also show that the Alfalfa plant is highly affected with the difference of concentration type more than B. subtilisbacteria.

From the previous data shown from fig 1 to 4 Although Alfalfa had the higher efficiency in removing chromium from soil but B. subtilis bacteria shown the higher efficiency in removal cadmium and nickel

Conclusion

Remediation is any process chemical, physical or biological or a combination that is either introduced or enhanced in order to reduce the concentration of heavy metal(s) in soil or water at contaminated sites.

The variation in heavy metals concentrations could be related to the movement of heavy metals from the discharge points to other places due to the water movement by wind action and the interaction between sediments and overlying water.

From the provirus result the presented study shown that the microbial removal is fast than using Alfalafa plant in removal and the biomass result from the bacteria is small and can removed to landfill easily than the plant tissue.

Also, the biomass result from collecting the heavy metal by bacteria is smaller than the plant biomass. the time of growing bacteria (24 hr) is better than that of plants (14 days).

Recommendation

The study recommended that using Bacillus subtilis bacteria in removal of heavy metals from the water and soil.

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