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Innovating new methods for wastewater treatment in El-Dakhla Oasis in Upper Egypt from chemical and biological pollutants using modified Down Flow Hanging Sponge (DHS) reactor in presence of new environmental friendly chelator

Abdou Saad El Tabl; Sameh Zawam; Karem Shawky Sarhan2 *

Chemistry Department, Faculty of Science, Menoufia University, Egypt

Abstract

Modified Down Flow Hanging Sponge (DHS) reactor will be a smart water treatment technology in the near future. It has advantages like low cost, ease of use and satisfaction level. One of the major geoenviromental problems in El-Dakhla region arises from the hazards exploitation of groundwater resources and sewage dumping which have resulted in waste water accumulation in the form of ponds. The most common pollutants are heavy metals, organic residue and microbes. The reactor was used for excellent removal of notorious heavy metals, organic pollutants and harmful microbes. In order to achieve these objectives, treatment scheme has been investigated. It consists of mixing new organic chelator with wastewater in different concentrations followed by a Down Flow Hanging Sponge (DHS) reactor. The residual values of heavy metals were (Mn) amount decreased from 1.00 ppm to zero ppm (100%) after 60 min.,(Fe) decreases from 0.997 ppm to zero ppm (100%) after 60 min. (Cd) decreased from 0.901 ppm to zero ppm (100%) after 60 min. (Cu) decreased from 1.1 ppm to zero ppm (100%) after 60 min. (Pb) decreases from 1.004 ppm to zero ppm (100%) after 60 min. (Ni) decreased from 0.922 ppm to 0 ppm (100%) after 60 min. The results show that removals of fecal coliforms were achieved. From the results of DHS effluent, fecal coliforms decreased from 5.2x106 to 200 and the overall removal efficiency of fecal coliforms was (99.99%) at 37Co.

Keywords: DHS reactor, organic chelator, heavy metal, fecal coliforms.

1. Introduction

Water is the most important and essential component on the earth for vital activities of living beings. Unfortunately, water quality from water resources is deteriorating continuously due to geometrical growth of population, industrialization, civilization, domestic, agricultural activities and other geological and environmental changes. [1–3] Therefore, water pollution has become a serious issue in the present scenario, affecting all living creatures, household, recreation, fishing, transportation, and other commercial activities. [4–6] The government authorities, scientists and academicians are worried and serious on this issue. Thousands of organic, inorganic, and biological pollutants have been reported as water contaminants. [7] Some of them have serious side effects and toxicities with a few being lethal and carcinogenic. [8–10] These pollutants are very dangerous for aquatic conditions and the ecosystem of the earth as a whole. Some heavy metals are notorious water pollutants with high toxicity and carcinogenicity. [11] Metal ions such as cadmium, chromium, copper, zinc, cobalt, mercury, selenium and lead, etc. have serious toxicities at higher concentration than the permissible limit [12–15]. Cobalt causes vomiting, nausea, asthma, and carcinoma. Besides, cobalt is also responsible for thyroid, gastrointestinal and liver problems. [16–18] Zinc is required for the growth of human beings, but high concentrations more than the permissible limit [3.0 mg/L] cause poor growth and mental fever. [19–21] Besides, nitrate, sulfate, phosphate, fluoride, chloride,

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and oxalate have also some hazardous effects. For example, high concentration of nitrate results into blue babies disease (methemoglobin) in children. [22] On the other hand, it is well-known that, fluorosis appeared is due to high levels of fluoride in water. [23] Many organic pollutants have been found in different water resources. These belong to various classes such as pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, greases, pharmaceuticals, etc. [23, 24, 25]. The side effects and toxicities of these contaminants were previously reported. [24, 26, 27] The different types of microbes present in wastewater may be responsible for various diseases. The harmful microbes are virus, bacteria, fungi, algae, amoebas, and planktons. These water pollutants remain either in soluble, colloidal, or in suspended form. These microbes are responsible for causing several illnesses called waterborne diseases. [28, 29] Because of these sorts of pollution, the surface and groundwater at some places of the world are contaminated, being unfit for drinking purposes. By 2020, the global population is expected to reach up to 7.9 billion, and because of this the world may be under great water scarcity. Therefore, the removal of these pollutants from contaminated water is considered an urgent need for providing disease-free health to our society [30]. The DHS post treatment system is designed for application in developing countries as it yields positive energy balance and produces less amount of excess sludge. The principle of this system is the use of polyurethane sponge as a medium to retain biomass. The concept is somewhat similar to that of trickling filter, except that the packing material is sponge, which can avoid space of more than 90%, resulting in a significant increase in entrapped biomass and leads thus to longer solid retention time (SRT). As the sponge in DHS is not submerged and freely hung/placed in the air, oxygen gets dissolved into the wastewater as it flows down and therefore there is no need of aeration or any other energy input to the system. Moreover, production of excess sludge from DHS becomes negligible as longer SRT provides ample time for autolysis of sludge in the system itself. Wastewater is trickled from the top of the reactor and purified by microorganisms retained both inside and outside of the sponge media as the wastewater flows vertically down through the reactor. The system demonstrated removal efficiency consistently over 95% for unfiltered biochemical oxygen demand (BOD), 80% for unfiltered-chemical oxygen demand and 70% for suspended solids. Moreover, excess sludge production from DHS was negligible thus eliminating secondary sludge that was troublesome. A pilot-scale DHS (0.38 m^3, volume of sponge) for treating municipal sewage was investigated.

2. Materials and Method

2.1. Area of the study:

Fig.1. Location of El-Dakhla Oasis- new vally Government-Upper Egypt

2.2. Down flow hanging sponge (dhs) system:

The DHS module column as shown below consists of four identical segments connected vertically, each segment was equipped with 25 L of polyurethane foam (PF) wrapped with plastic material randomly distributed in the whole reactor. The DHS system was made of PVC, with a capacity of 0.22 m^3 and has an internal diameter of 0.16 m. The height of the reactor is 0.88 m. The reactor will be filled with PF which represents 34% of the total liquid reactor volume. The characteristics of the PF (sponge) were as follows: surface area 256m^2/m^3, density 30 kg/m^3, void ratio 0.9, and pore size of 0.63 mm. The total volume of the PF will be 100 L Fig (2). The dimensions of the used sponge (PF) (cylindrical shape) is 27mm height × 4mm diameter. The Wastewater effluent can be flowed by gravity to the distributor which was located on the top of the DHS module and will be rotated at 15 rpm. Chemical parameters such as COD, BOD, TSS, TDS, NO_2 and NO_3 were monitored at retention time 6 h and 3h according to APHA (2005) "Standard Methods for the Examination of Water and Wastewater".

2.3. Synthesis of the organic chelator:

Synthesis of the chelator: oxalic (20.0 g, 1.04mol) was boiled in ethanol for 1h. Five drops of conc. H_2SO_4 were added, and continuously refluxed to three hrs. (18.0 g) of phenyl hydrazine was added. The mixture was refluxed with stirring for another three hrs

and the brown precipitate which formed was washed with ethanol and dried in air. The preparation of the chelator is represented in Fig. (3).

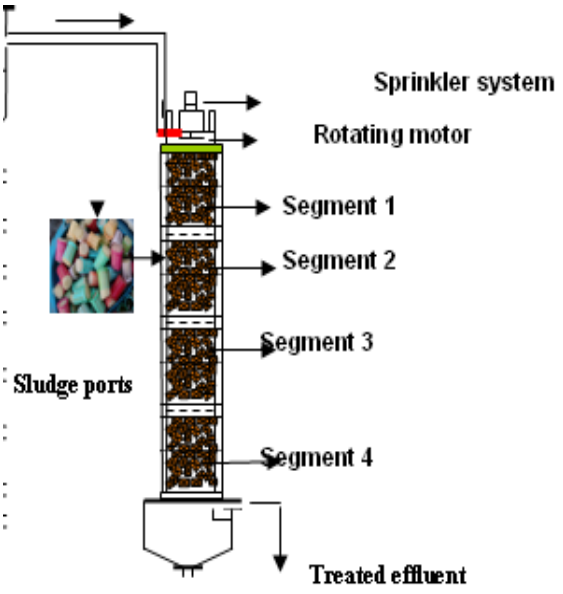


Fig. (2) DHS system

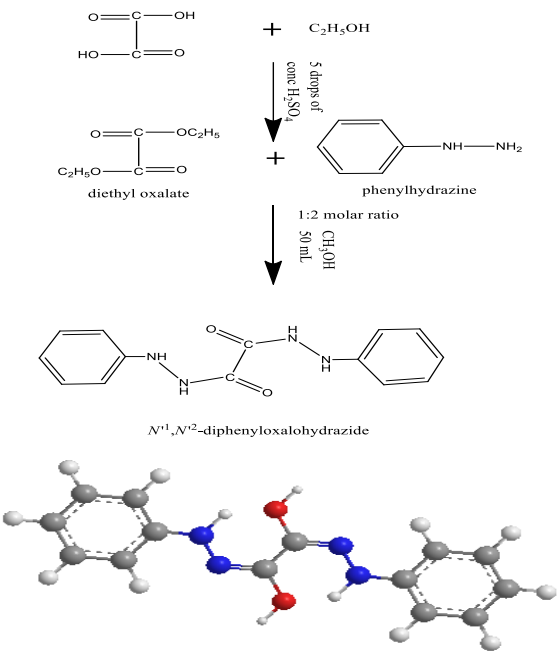
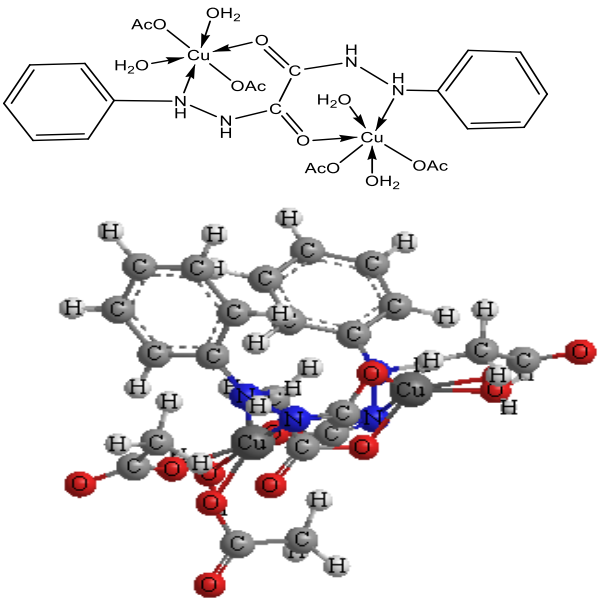


Fig (3): Structure of the chelator and 3D.

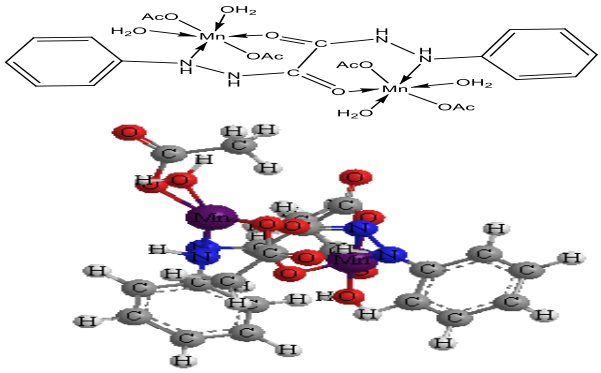
Ligand (**1**): Yield 85%; m.p. >300; color was brown; calculated values for elemental analyses for $C_{14}H_{14}N_4O_2$ (FW=270.11): C, 62.21; H, 5.22; N, 20.73, Found (%) C, 62; H, 5.62; N, 21, IR (KBr, cm−1), 3190, 3120 υ(NH), 1700 and 1675 υ(C=O), Ar, 1545, 800. The mass spectrum of the chelator revealed molecular ion peak at m/z 270.11, the H^1-NMR gives peaks at 5.3 ppm (NH amide), 7.82 ppm (NH-Ar) and 6.3-7.8 ppm (Ar) which confirmed its structure.

2.4. Preparation of metal complexes:

Metal complexes are prepared by heating with continuous stirring 1-2 hrs range at 60ºC 30 cm^3 ethanolic solution of the chelator with (3.09, 0.01mol) 30 cm^3 ethanolic solution of a suitable metal salts of (4.03g, 0.02 mol) $Cu(CH_3COO)_2.H_2O$, complex (**2**), (3.84g, 0.02mol), $[Mn(OAc)_2.4H_2O]$ complex (**3**), (5.12g, 0.02mol), $[Cd(OAc)_2.4H_2O]$ complex (**4**), (5.52g, 0.02mol), $[Ni(OAc)_2.4H_2O]$ complex (**5**), (3.37g, 0.02mol), $[FeSO_4.3H_2O]$ complex (**6**) and (6.18g, 0.02mol), $PbCl_2$ complex (**7**). The formed precipitates are filtered off, washed several times with ethanol, dried over $CaCl_2$. The suggested structure of laboratory prepared metal complexes are shown in Fig(**4**)



Complex (2)



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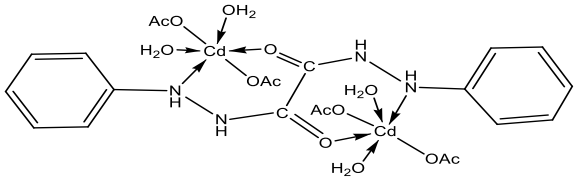
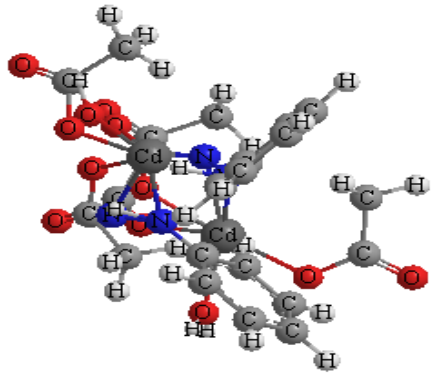
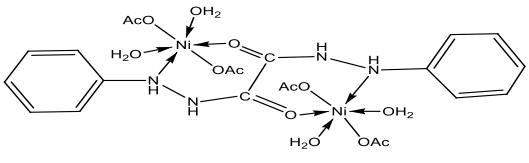
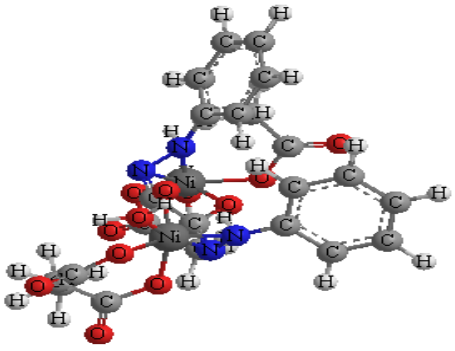


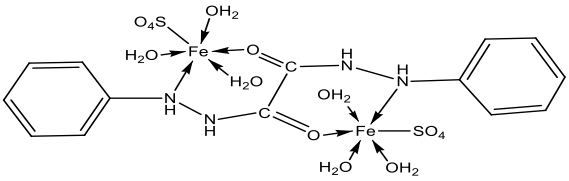


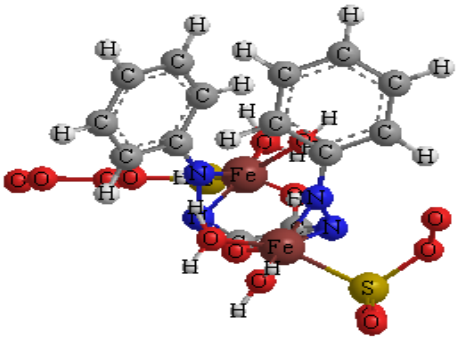
Complex (4)



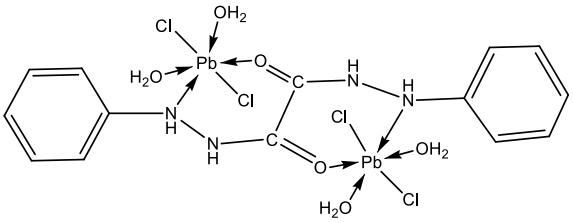


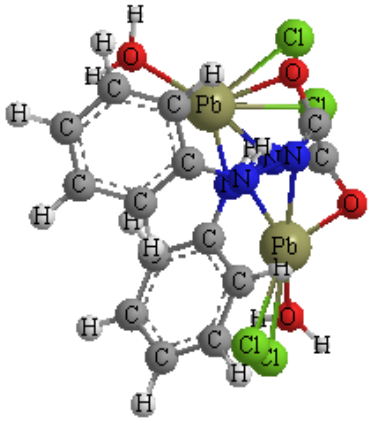
Complex (5)





Complex (6)





Complex (7)

3. Results and Discussion: -

El-Dakhla pond contains heavy metals like copper, nickel, lead, manganese and iron in high concentrations. In order to determine the capacity of the organic chelator to remove these metals from the wastewater pond. Metal complexes of this chelator have been prepared and studied at different conditions in the laboratory. The structure of the formed complexes had been characterized using elemental and spectroscopic measurements like IR, UV-Vis,

conductivity, thermal and ESR spectra. The elemental and spectral analysis confirmed octahedral structure for all complexes.

Complex (2): Chemical Formula: $C_{22}H_{34}Cu_2N_4O_{14}$, Molecular Weight: 705.62, Elemental Analysis: Calc:C, 37.45; H, 4.86; Cu, 18.01; N, 7.94, Found (%): C, 37.23, H, 4.61, Cu, 17.18, N, 7.52: IR (KBr, cm^{-1}), 3185 υ(NH), 1685, 1635 υ(C=O), 1532, 785 ν(Ar). U.V-Vis, 270, 305, 458, 548, 605nm, M_{eff} = 1.71 B.M. Λm= 7.23 $\Omega^{-1}cm^2mol^{-1}$, ESR, g_{II}= 2.18, $g_{\perp}$= 2.07, g_{iso}= 2.107

Complex (3): Chemical Formula: $C_{22}H_{34}Mn_2N_4O_{14}$, Molecular Weight: 688.40, Elemental Analysis: Calc: C, 38.38; H, 4.98; Mn, 15.96; N, 8.14; Found (%): C, 38.1, H, 4.65, Mn, 15.52, N, 7.92:IR (KBr, cm^{-1}), 3180, 3125 υ(NH), 1680, 1645 υ(C=O), 1537,780ν(Ar). U.V-Vis, 272, 310, 468, 570, 615nm, M_{eff} = 6.12 B.M. Λm= 8.35 $\Omega^{-1}cm^2mol^{-1}$, ESR, g_{iso}= 2.05.

Complex (4): Chemical Formula: $C_{22}H_{34}Cd_2N_4O_{14}$, Molecular Weight: 803.85, Elemental Analysis: Calc: C, 32.89; H, 4.27; Cd, 27.99; N, 6.97; Found (%): C, 32.31, H, 4.78, Cd, 27.51, N, 6.48, IR (KBr, cm^{-1}), 3185, 3133 υ(NH), 1680, 1638 υ(C=O), 1537, 790 ν(Ar). U.V-Vis, 275, 312nm, M_{eff} = Diamagnetic. Λm= 5.73 $\Omega^{-1}cm^2mol^{-1}$.

Complex (5): Chemical Formula: $C_{22}H_{34}N_4Ni_2O_{14}$, Molecular Weight: 695.91, Elemental Analysis: Calc: C, 37.97; H, 4.92; N, 8.05; Ni, 16.87; Found (%): C, 37.42, H, 4.78, Ni, 16.63, N, 7.65 IR (KBr, cm^{-1}), 3180, 3138 υ(NH), 1680, 1640 υ(C=O), 1540, 792 ν(Ar). U.V-Vis, 270, 306, 480, 545, 600 nm, M_{eff} = 3.23 B.M. Λm= 7.63 $\Omega^{-1}cm^2mol^{-1}$.

Complex (6): Chemical Formula: $C_{14}H_{26}Fe_2N_4O_{16}S_2$, Molecular Weight: 682.19, Elemental Analysis: Calc :C, 24.65; H, 3.84; Fe, 16.37; N, 8.21; Found (%): C, 24.1, H, 3.62, Fe, 15.92, N, 7.85 IR (KBr, cm−1), 3185,3142 υ(NH), 1685,1642 υ(C=O), 1540,795 ν(Ar). U.V-Vis, 271, 310, 460, 560, 610 nm, Λm= 9.85 $\Omega^{-1}cm^2mol^{-1}$.

Complex (7): Chemical Formula: $C_{14}H_{22}Cl_4N_4O_6Pb_2$, Molecular Weight: 898.56, Elemental Analysis: Calc : C, 18.71; H, 2.47; Cl, 15.78; N, 6.24; Pb, 46.12, Found (%): C, 18.25, H, 2.2, Pb, 45.85, N, 6.0 IR (KBr, cm^{-1}), 3175,3135 υ(NH), 1675,1635 υ(C=O), 1540,790 ν(Ar). U.V-Vis, 275, 315, 315nm, Λm= 6.75 $\Omega^{-1}cm^2mol^{-1}$.

3.1. Measurement of the capacity of the chelator (Metal removal efficiency)

Biosorption capacity (q_e) and the amount of metal adsorbed per gram of biosorbent, was calculated in mg/g as follows:

$$Q_e = (C_o - C_e)\, V/\, m$$

where, C_o is the initial metal ions concentration (mg/L), C_e is the equilibrium concentration of metal ions (mg/L), V is the volume of solution (L) and m is the mass of biosorbent (g). Percentage of metal removal was also be displayed by the percentage of metal removal as follows:

Metal removal (%) = 100($C_o - C_e$) / C_o

When the chelator was treated with the metal ions in (2:1) molar ratio in Fig (5), we found the removal efficiency after 60 min (70° C) was as follows: 75% for **(Mn)** , 48% for **(Fe)**, 54% for **(Cd)**, 76.7% for **(Cu)**, 44% for **(Pb)** and 57.5% for **(Ni)**.

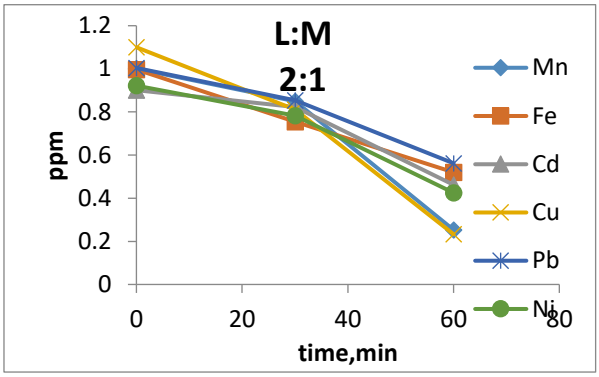


Fig.5: - Variation concentration of heavy metals at molar ratio (2:1)

When the chelator was treated with the metal ions in (1:2) molar ratio in Fig. (6), we found the removal efficiency after 60 min (70° C) was as follows: 22% for **(Mn)**, 37.5% for **(Fe)**, 15% for **(Cd)**, 27.5% for **(Cu)**, 38.5% for **(Pb)** and 21% for **(Ni)**.

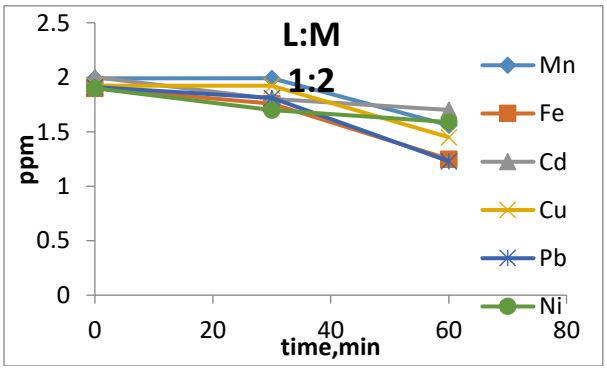


Fig.6: - Variation concentration of heavy metals at molar ratio (1:2)

When the chelator was treated with the metal ions in **(3:1)** molar ratio in Fig. (7) we found the removal efficiency after 60 min (70º C) was as follows 85% for **(Mn)**, 77% for **(Fe)**, 75% for **(Cd)**, 87% for **(Cu)**, 85% for **(Pb)** and 66% for **(Ni)**.

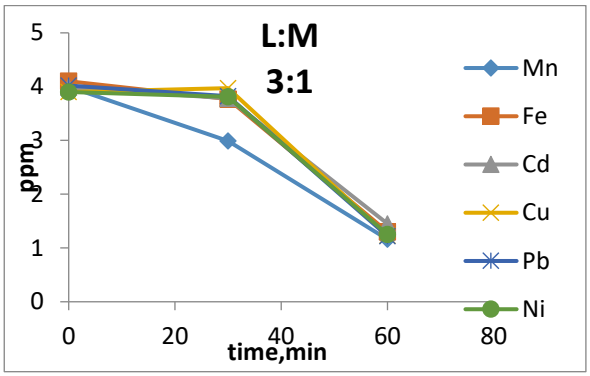


Fig.7: - Variation concentration of heavy metals at molar ratio (3:1)

When the chelator was treated with the metal ions in **(4:1)** molar ratio in Fig. (8), we found the removal efficiency after 60 min (70º C) was as follows 100% for **(Mn)**, 100% for **(Fe)**, 100% for **(Cd)**, 100% for **(Cu)**, 100% for (Pb) and 100% for **(Ni)**.

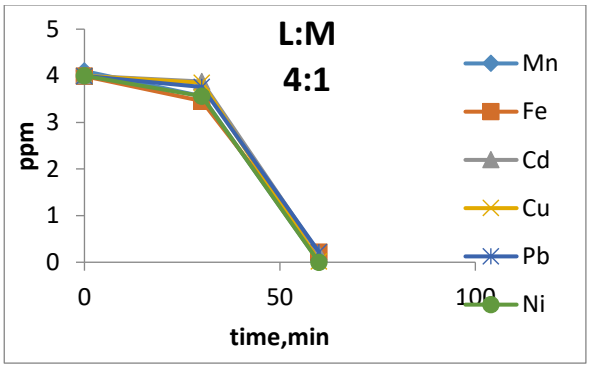


Fig.8: - Variation concentration of heavy metals at molar ratio (4:1)

3.2. DHS performance as post-treatment at RHT 6h in absence of chelator

Differences in the types of wastewater treatment technology and comparison between them using chemical parameters such as Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD) at retention time 6h are demonstrated as follows:

3.2.1. The application of (DHS) system

3.2.1.1. Chemical oxygen demand (COD) removal

Based on these results, the DHS system is considered a good alternative post- treatment system. Studies carried out included physical factors such as retention time, sponge pore size. The measured COD concentration in the treated effluent of DHS was (35±10%) (Fig.9) Excellent COD removal was rapidly established in all the reactors, which was one of the DHS systems merits. This was attributed to the temporary adsorption of organic substances onto the sponge media. The results obtained indicated that the COD decreases from 45% in primary effluent to 85% in the DHS effluent. This could be attributed to the particulate matter entrapment and degradation in DHS sponge by virtue of its long retention time.

3.2.1.2. Biological oxygen demand (BOD) and TSS removal

The removal efficiency of BOD in DHS was (30.23±10 %). The removal efficiency of TSS was (65.10±12%) in the DHS system. Suspended solids were entrapped and degraded in the sponge of the DHS system as illustrated in (Figs.10 and 11).

3.2.1.3. Nitrogen balance and removal efficiency

Regarding nitrogen removal, it was observed that the mode of nitrogen removal in the DHS reactor was nitrification followed by denitrification. The nitrified residing in the retained wastewater of DHS reactor was shown first convert ammonia to nitrite and nitrate which were shown first converted to gaseous nitrogen by denitrification in the anoxic zone of the sponge material. Variations in nitrite and nitrate concentrations are shown in Figs. (12 and 13) respectively. Nitrate concentrations in the DHS effluent were fluctuated were between 1.7 and 1.86mg/l. and nitrite concentrations in the DHS effluent were fluctuated were between 1.45 and 1.84mg/l. Nitrification in DHS took place in the lower portion of the reactor where the increase in the nitrate and nitrite can be due to the nitrification by nitrobacteria.

3.2.1.4. Fecal coliform removal

Removal of pathogenic organisms is one of the main objectives of municipal wastewater treatment for developing countries as it signifies the risk factor for public health. Many countries like Egypt have

stringent standards regarding the presence of pathogens in treated wastewater as they directly affect the health and sanitation conditions of the population. [31] In the present study, fecal coliform was chosen as an indicator for pathogenic organisms. It was well understood that anaerobic reactors do not significantly contribute to the removal of coliforms [32]. However, relatively good results were achieved using the DHS reactor. The geometric mean of fecal coliform count in the DHS reactor effluent was reduced by 99.9%. The relatively higher performance could be due to adsorption and bio-filtration of fecal coliform by curtain sponge packing in the sedimentation section of the DHS reactor. Furthermore, a substantial drop of fecal coliform counts had been reported in the final effluent with residual count of 200 MPN/100 ml. These results indicated that the DHS reactor was more effective for the removal of fecal coliform as compared to other previously used aerobic systems. [33] It was found that rotating biological contactor (RBC) system treating domestic wastewater had achieved a reduction in fecal coliform count of 99.9%. Also, one likely reason of the higher performance of DHS reactor could be the higher amount of retained wastewater and long SRT[34]. In a recent study, the mechanism of fecal coliform removal in DHS reactor effluent was investigated. The results showed that the removal efficiency of fecal coliform removal efficiencies in DHS was 99.9%(200±50unit/100ml), where sponge bulk volume was found to be the most important factors affecting entrapment of fecal coliform in DHS treating system. (Fig.14)

3.3. The performance results of dhs system in treating domestic wastewater at a total HRT of 6 h (runs 1, 2, 3,4 and 5)

Table (1): -RUN1

S	Parameter	Unit	Result	
			Raw 1	Run 1
1	pH	Unit	7.01	7.25
2	TDS	ppm	506	376
3	TSS	ppm	150	76
4	COD	ppm	300	145
5	BOD	ppm	175	108
6	Nitrite (NO_2)	ppm	1.42	1.88
7	Nitrate (NO_3)	ppm	1.6	1.77
8	Conductivity	µS/cm	662	455
9	Fecal Coliform	CFU/100mL	4.25×10^6	2.5×10^6

Table (2): - RUN 2

S	Parameter	Unit	Result	
			Raw 2	Run 2
1	pH	Unit	7.21	7.55
2	TDS	ppm	466	285
3	TSS	ppm	135	65
4	COD	ppm	320	164
5	BOD	ppm	180	96
6	Nitrite (NO_2)	ppm	1.27	1.45
7	Nitrate (NO_3)	ppm	1.24	1.85
8	Conductivity	µS/cm	585	365
9	Fecal Coliform	CFU/100mL	2.2×10^6	1.12×10^6

Table (3): -RUN 3

S	Parameter	Unit	Result	
			Raw 3	Run 3
1	pH	Unit	7.5	7.52
2	TDS	ppm	345	218
3	TSS	ppm	148	76
4	COD	ppm	335	145
5	BOD	ppm	210	102
6	Nitrite (NO_2)	ppm	1.2	1.46
7	Nitrate (NO_3)	ppm	1.44	1.67
8	Conductivity	µS/cm	415	256
9	Fecal Coliform	CFU/100mL	3.2×10^6	1.54×10^6

Table (4): -RUN 4

S	Parameter	Unit	Result	
			Raw 4	Run 4
1	pH	Unit	7.03	7.21
2	TDS	ppm	482	420
3	TSS	ppm	170	74
4	COD	ppm	380	268
5	BOD	ppm	230	162
6	Nitrite (NO_2)	ppm	1.21	1.26
7	Nitrate (NO_3)	ppm	1.20	1.40
8	Conductivity	µS/cm	660	440
9	Fecal Coliform	CFU/100mL	4×10^6	2×10^6

Table (5): -RUN 5

S	Parameter	Unit	Result	
			Raw 5	Run 5
1	pH	Unit	7.90	7.21
2	TDS	ppm	480	425
3	TSS	ppm	195	123
4	COD	ppm	317	200
5	BOD	ppm	180	119
6	Nitrite (NO_2)	ppm	1.38	1.86
7	Nitrate (NO_3)	ppm	0.60	1.84
8	Conductivity	µS/cm	580	370
9	Fecal Coliform	CFU/100mL	2×10^6	3×10^5

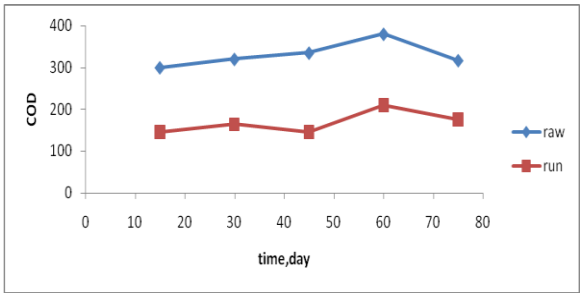


Fig.9: Variation in total COD along DHS treatment system

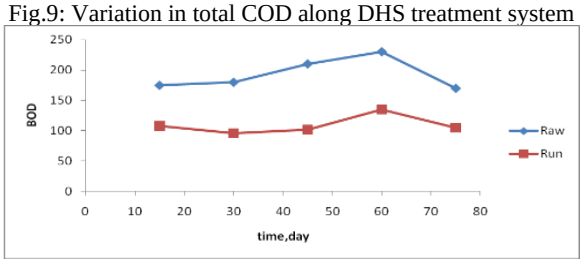


Fig.10: BOD total variation along DHS treatment system

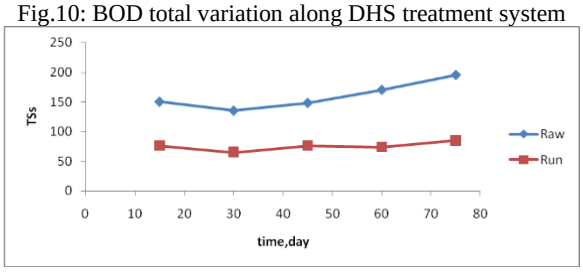


Fig.11: Variation in TSS along DHS treatment system

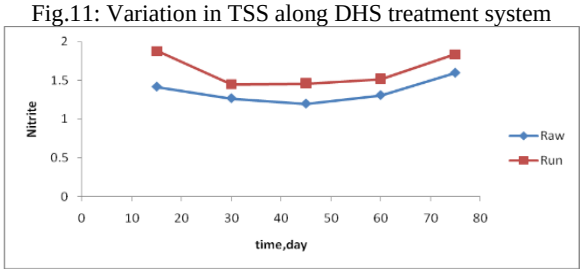


Fig.12: Variation in nitrite (NO2) along DHS treatment system

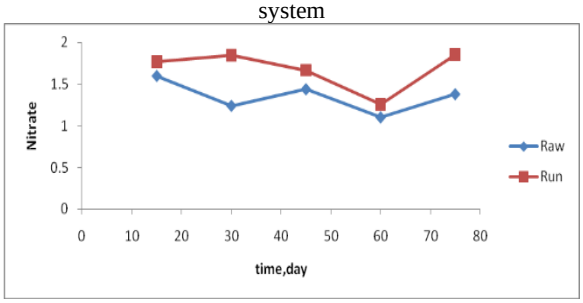


Fig.13: Variation in nitrate (NO3) along DHS treatment system

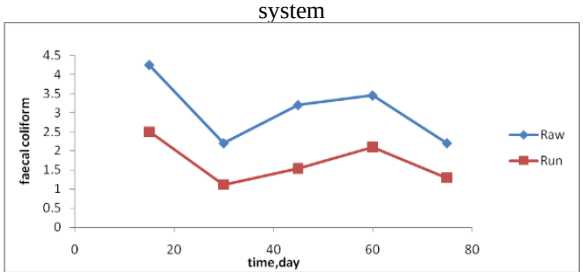


Fig.14: Variation in Fecal Coliform along DHS treatment system

3.4. The Performance results of heavy metals removal at (0.7 g/l of and 1.4 gL-1 from The chelator) as illustrated in Tables (6 and 7) and Figs. (15, 16)

3.4.1. DHS performans as post-treatment at RHT (3h) in presence of chelator (at 0.7 gl^{-1} from the chelator):

3.4.1.1. Heavy metals removal efficiency

The obtained results showed that the residual values of **(Cu)** when treated with chelator decrease from 0.213 to 0.089 mgL^{-1} (58.2%), while these of **(Mn)** decreases from 0.102 to 0.01 mgL^{-1} (90.19%), for **(Cd)** they decrease from 0.174 to 0.064 mgL^{-1} (63.21%),for **(Ni)** they decrease from 0.562 to 0.245 mgL^{-1} (56.40%),for **(Fe)** they decreased from 1.148 to 0.115 mgL^{-1}(90%), for **(Pb)** they decreased from 0.146 to 0.031 mgL^{-1}(78.7%). Particles of heavy metals should be absorbed or adsorbed and captured in the surface of the chelator surface area. Particles to be digested, it should be captured first and the digestion and the biodegradation processes will be then occurred in the land. Available data indicate good performance of the chelator in regard to heavy metals removal efficiency as shown in fig. (**15**).

3.4.1.2. Bacterial treatment

The obtained results showed that, the residual values of fecal coliform when treated with chelator, the amount decreases from 2.4 x10^{5}to 3.2x10^{3}MPN index /100 ml (99.99%).

3.4.2. DHS performance as post-treatment at RHT 3h in presence of chelator (at dose 1.4 gl-1 from the chelator)

3.4.2.1. Heavy metals removal efficiency:

The results showed that the residual values of heavy metals was followed as: (86.55%) for **(Cu)** when treated with chelator, the amount decreased from 0.186 to 0.025 mgL^{-1}, (100%) for **(Mn)** decreased from 0.10 to zero mgL^{-1}, (74.38%) for **(Cd)** decreased from 0.374 to 0.021 mgL^{-1}, (89.2%) for **(Ni)** decreased from 0.232 to 0.025 mgL^{-1}, (72.08%) for **(Fe)** decreased from 1.125to 0.314 mgL^{-1}, (97.88%) for **(pb)** decreased from 0.142 to 0.003 mgL^{-1} as shown in fig. (**16**).

3.4.2.2. Bacterial treatment

The result showed that the residual values of Fecal coliform when treated with the chelator had

decreased from $5.2x10^6$ to 200 MPN index /100 ml (99.99%).

Table (6) :(0.7 gL-1 of chelator)

Parameters		Unit	Raw	Run
Heavy metals	Cu	mgL^{-1}	0.213	0.089
	Mn	mgL^{-1}	0.102	≤ 0.01
	Cd	mgL^{-1}	0.174	0.064
	Ni	mgL^{-1}	0.562	0.245
	Fe	mgL^{-1}	1.148	0.115
	Pb	mgL^{-1}	0.146	0.031
Fecal Coliform		unit/l00ml	$2.4 x10^5$	$3.2x10^3$

Table (7) :(1.4 gL-1 of chelator)

Parameters		Unit	Raw	Run
Heavy metals	Cu	mgL^{-1}	0.186	0.025
	Mn	mgL^{-1}	0.100	0
	Cd	mgL^{-1}	0.374	0.021
	Ni	mgL^{-1}	0.232	0.025
	Fe	mgL^{-1}	1.125	0.314
	Pb	mgL^{-1}	0.142	0.003
Fecal Coliform		unit/l00ml	$5.2x10^6$	200

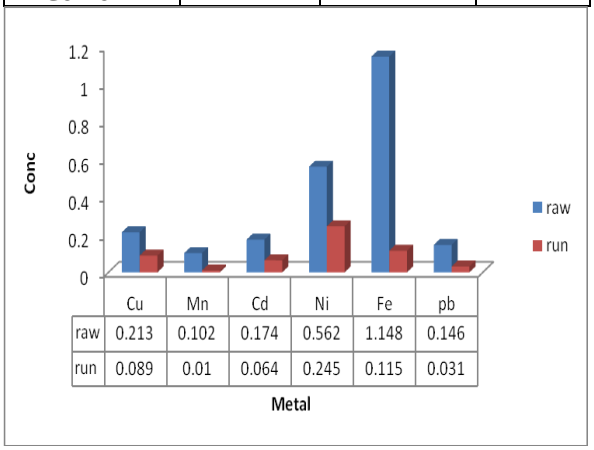
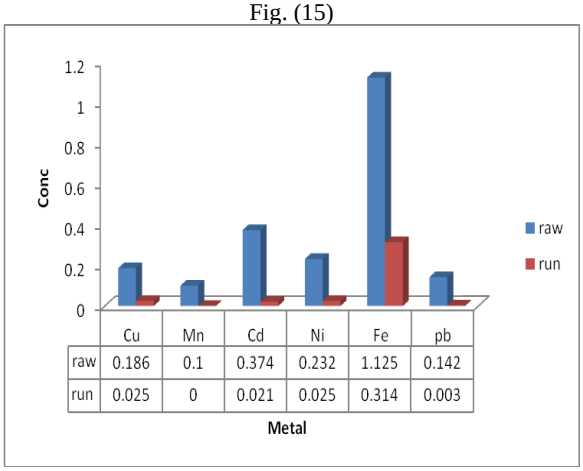


Fig. (15)



Figs. (16)

4. Conclusion

Modified down flow hanging sponge (DHS) reactor provides low cost and satisfaction level of physico-chemical treatment of wastewater in El-Dakhla region. The most common pollutants are heavy metals, organic residue and microbes. The reactor side by side with the organic chelator was used for excellent removal of notorious heavy metals, organic pollutants and harmful microbes. The DHS system is considered a good alternative post- treatment system for wastewater.

5. References

[1] Nemerow, N.; Dasgupta, A. Industrial and Hazardous Waste Treatment, *Van Nostr and Reinhold: New York*, 1991.

[2] Tchobanoglous, G; Franklin, L. B. Wastewater Engineering: Treatment, Disposal and Reuse; *McGraw Hill, Inc.: New York*, 1991.

[3] Kassab, G., Halalsheh, M., Klapwijk, A., Fayyad, M., Van Lier, J.B. Sequential anaerobic–aerobic treatment or domestic wastewater – A review. *Bio resource Technology*, 101: 3299–3310 (2010).

[4] Ali, I.; Aboul-Enein, H. Y. Chiral Pollutants: Distribution, Toxicity and Analysis by Chromatography and Capillary Electrophoresis; *John Wiley & Sons: Chichester, UK*, 2004.

[5] Franklin, L. B. Wastewater Engineering: Treatment, Disposal and Reuse, McGraw Hill Inc.: New York, (1991).

[6] Okubo, T., Onodera, T., Uemura, S., Yamaguchi, T., Ohashi, A., Harada, H. Bio resource Technology 194: 156-164 (2015).

[7] Droste, R. L. Theory and Practice of Water and Wastewater Treatment; *John Wiley & Sons: New York*, 1997.

[8] John, D. Z. Handbook of Drinking Water Quality: Standards and Controls, *Van Nostr and Reinhold: New York*, 1990.

[9] Laws, E. A.Aquatic Pollution: An Introductory Text, 3rd ed.; *John Wiley & Sons: New York*, 2000.

[10] Ali, I.; Aboul-Enein, H. Y. Instrumental Methods in Metal Ions Speciation: Chromatography, Capillary Electrophoresis and Electrochemistry; *Taylor & Francis Ltd.: New York*, 2006.

[11] Onodera, T., Matsunaga, K., Kubota, K., Taniguchi, R., Harada, H., Syutsubo, K., Okubo, T., Uemura, S., Araki, N., Yamada, M., Yamauchi, M., Yamaguchi, T. *Bio resource Technology*, 136:169–175 (2013).

[12] Ali, I.; Aboul-Enein, H. Y.; Gupta, V. K. Nano Chromatography and Capillary Electrophoresis: Pharmaceutical and Environmental Analyses; *John Wiley & Sons: Hoboken, NJ*, 2009.

[13] Vettorazzi, G. International Regulatory Aspects for Pesticide Chemicals; *CRC Press Inc.: Boca Raton*, FL; Vol. 1, p14 (1979).

[14] Zhu, C.; Luan, Z.; Wang, Y.; Shan, X.Sep. Purif. *Technol*.,57, 161-2007.

[15] Marin, A. B. P.; Zapata, V. M.; Orturao, J. F.; Aguilar, M.; Saez, J.; Lloren, M. J. *Hazard. Mater.*, 139, 122-2007.

[16] Sigel, H.; Sigel, A. Concepts on Metal Ion Toxicity; Marcel *Dekker, Inc.: New York*, 1986.

[17] Onodera, T., Tandukar, M., Sugiyana, D., Umbra, S., Ohashi, A., Harada, H. *Bio resource Technology*, 152: 93–100(2014a).
[18] Smiciklas, I.; Dimovic, S.; Plecas, I.; Mitrio, M. Water. Res.,40, 2267- 2006.
[19] (19) Guidelines for Drinking-Water Quality, 2nd ed.; *World Health Organization: Geneva*, Vol.1-1993.
[20] Meyers, R. A., Ed. Encyclopedia of Environmental Pollution and Clean-up; *John Wiley & Sons*: New York, (1999).
[21] Damia, B., Ed. Emerging Organic Pollutants in Waste Waters and Sludge; *Springer: New York*, 2005.
[22] Persistent Organic Pollutants: Impact on Child Health; NLM classification: WA 671, *WHO report; World Health Organization: Geneva*, 2010.
[23] Kohler, A.; Hellweg, S.; Escher, B. I.; Hunger buhler, K. Environ. *Sci. Technol.*, 40, 3395-2006.
[24] Dyson, T. Population and Food: Global Trends and Future Prospects; *Routledge: London*, (1996).
[25] Abdou Saad El-Tabl and Karem Shawkey Sarhan, *Journal of Chemistry and Chemical Sciences*, Vol. 7(6), 110-129, Jun 2017.
[26] Abdou Saad El-Tabl, Karem. S. Sarhan and Ahmed Behery, *Journal of Chemistry and Chemical Sciences*, Vol.9 (12), 366-379, December, 2019.
[27] Abdou Saad El-Tabl* and Mahmoud Sayed Ahmed Shahin, Groundwater Remediation from Chemical and Bacteriological Pollutants Using Modified DownFlow Hanging Reactor, *Journal of Chemistry and Chemical Sciences*, Vol.8(3), 524-537, March, 2018.
[28] Rahul Sujanani, Matthew R. Landsman, Sally Jiao, Joshua D. Moon, M. Scott Shell, Desmond F. Lawler, Lynn E. Katz, Benny D. Freeman. Designing Solute-Tailored Selectivity in Membranes: Perspectives for Water Reuse and Resource Recovery. *ACS Macro Letters*, 9 (11) , 1709-1717, 2020
[29] N.S. Elshemy, S.H. Nassar, N.M. El-Taieb, A.A.A. Shakour, A.M. Elmekawy, A.G. Hassabo, Effect of different fabrics types on the adsorption of air pollution in residential and industrial atmosphere in Cairo-Egypt, Letters in Applied NanoBioScience 9(4) (2019) 682 - 691.
[30] Water Scarcity and Humanitarian Action: Key Emerging Trends and Challenges, *Occasional Policy Briefing Series, Brief No. 4:* September 2010
[31] Zahra Aghalari, Hans-Uwe Dahms et al, Effectiveness of wastewater treatment systems in removing microbial agents: a systematic review, Globalization and health, Article number: 13 (2020)
[32] Asad Sarwar Qureshi, Challenges and Prospects of Using Treated Wastewater to Manage Water Scarcity Crises in the Gulf Cooperation Council (GCC) Countries, *Water*, 12(2020)
[33] Bingjian Cui and Shengxian Liang , Monitoring Opportunistic Pathogens in Domestic Wastewater from a Pilot-Scale Anaerobic Biofilm Reactor to Reuse in Agricultural Irrigation, *Water*, 11(2019)
[34] A. Tawfik, B. Klapwijk, F. El-Gohary and G. Lettinga, Treatment of anaerobically treated domestic wastewater using rotating biological contactor, *Water* Science & *Technology*, 10.2166/wst.2002.0371 (2002)