Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2017 14(3): 633-644. **OPEN ACCESS**

Microorganism as a tool of bioremediation technology for cleaning waste and industrial water

Abou Seeda M. A[1], Yassen A. A.[1] and E.A.A. Abou El-Nour[2]

[1] Plant Nutrition Dept" National Research Centre, 33 El-Bohouth st. Dokii, Giza-P.O. 12622 **Egypt.**
[2] Fertilization Technology Dept. National Research Centre33 El-Bohouth st. Dokii, Giza-P.O. 12622 **Egypt**

.***Correspondence: mabouseeda@gmail.com** **Accepted:** 04 Aug. 2017 **Published online:** 30 Sep. 2017

Egypt, suffer from limited water resources and will face water deficiency problem. The non-conventional water resources as well as reuse will be the only option to overcome this problem as well as preventing environmental pollution. Results revealed that application of industrial wastewater effluent with more effective microorganisms (*MEM*)at rates of 0.5, 1.0 and 1.5 g/m^3 reduced the pH by about 10, 12 and 14% particularly under non-aeration condition. Nevertheless, under aeration circumstances the reductions of pH was more pronounced. It was noticed that lowering pH of the treated water might be relate to the destruction of organic material, creating organic acid, which reduce the p^H. Results revealed that application of MEM at different rates gradually reduced the organic compounds. Averages of decrease were 41, 44 and 48%. Whereas, under aerobic condition, the percentages of removal were gradually increased by about 62, 72 and 92% at rates of 0.5, 1.0 and 1.5% g.m^{-3} respectively.Results also showed that, minimum removal (22%), of *BOD* was noticed at a rate of 0.5 g.m^{-3} particularly under non-aerobic condition while maximum removal was observed under aerobic condition (91%). Results revealed that application of *MEM* of industrial wastewater effluent stimulated the reduction of the investigated heavy metal.It was noticed that bio-treatment application sharply decreased the biological oxygen demand *(BOD)* for sewage wastewater effluent. Under non-aeration condition, percentages of removal of *BOD* were 40, 47 and 54 particularly after one day of the treatment. Nevertheless, bio-treated sewage effluent under aeration gradually reduced the *BOD*, percentages of removal were 77, 86 and 94% at 0.5, 1.0 and 1.5 g.m^{-3} of *MEM* respectively. This paper explores the advantages of the more effective microorganisms *(MEM)* for the biological treatment for both industrial and wastewater effluent, and will highlights area where, further research must be done before this technology can be used on a wide scale

Keywords: Bioremediation, sewage effluent, industrial wastewater, BOD, COD, heavy metal

INTRODUCTION

Egypt, suffer from limited water resources and will face water deficiency problem. The non-conventional water resources as well as reuse will be the only option to overcome this problem as well as preventing environmental pollution. Sustainable water management in combination with high efficiency treatment of the contaminated and wastewater for the purpose of water reuse is the only way to meet this challenge. Contaminated water with petroleum oil and its components is common in the oil producing and industrialized countries of the world .It is a considerable threat to the environment and to human health (Al-Baldawi et al. 2015). The principal objective of waste and industrial water treatment is generally to allow human and industrial effluents to be disposed without danger to unacceptable damage to the natural environment (Kumar et al. 2012). It has been known to affect a variety of biological processes and may exhibit a wide range of hazardous effects to aquatic organisms Gaspare et al. 2009; Mates et al. 2010; Huang et al. 2012). Some degree of treatment must normally be provided to raw municipal wastewater before it can be used for agricultural or landscape irrigation or for aquaculture. The quality of treated effluent used in agriculture has a great influence on the operation and performance of the wastewater-soil - plant (Lopez, et al. 2006; Rubino et al. 2008; Vivaldi et al. 2013).

The most appropriate wastes and industrial wastewater treatment to be applied before effluent use in agriculture is that which will produce on effluent meeting the recommended microbiological and chemical quality guidelines both at low cost and with minimal operational and maintenance requirements (Arar 1988 and Lessinger, 1996). Adopting as low level of treatment as possible is especially desirable in developing countries, not only from the point of view of cost but also in acknowledgement of the difficulty of operating complex systems reliably. In many locations, it will be better to design the reuse system to accept a low-grade of effluent rather than to rely on advanced treatment processes producing a reclaimed effluent that continuously meets a stringent quality standard.

The term bioremediation has been introduced to describe the process of using biological agent to remove toxic wastes from environment. Bioremediation is the most effective management tools to many the polluted waste and recover contaminated wastewater. It is an attractive and successful cleaning technique for polluted environment; it has been used at a number of sites worldwide with varying degrees of success. Bioremediation both in situ and ex situ have also enjoyed strong scientific growth in parts of the world due to the increased use of natural attenuation, since most natural use attenuation is due to biodegradation. Microbes are very helpful to remediate the contaminated environment. Various microbes including aerobes, an aerobes and fungi are involved in bioremediation process. Bioremediation is engineered process that uses microorganisms to destroy, degrade, detoxify or remove environmental hazardous pollutants, and transform them into less complex and harmless products such as carbon dioxide and water (Coulon et al. 2010; Malik and Ahmed, 2012; Dell'Anno et al. 2012; Alwan et al. 2013; Gomez and Sartaj, 2014; Dellagnezze et al. 2014; Hassanshahian, et al. 2014).

This paper explores the advantages of invention called more effective microorganisms *(MEM)* for the biological treatment for both industrial and wastewaters from the natural gases fields and sewage water effluents through the enzymatic reaction.

MATERIALS AND METHODS

Invention and composition of MEM:

More effective microorganisms *(MEM)* are produced through a natural process of fermentation and neither chemical neither synthesized nor genetically engineered. More effective microorganisms (*MEM)* are combination of various beneficial, naturally occurring microorganisms mostly used for or found in food. It includes both aerobic and anaerobic species coexisting symbiotically in a most beneficial productive manner. Microorganisms that are more effective *(MEM)* through adding macro and micronutrients always, secrete beneficial substances such as vitamins, organic acids, chelated minerals and antioxidants when content with organic matter.

Water samples:

Representative water samples from Industrial and wastewater effluents were collected. Well water from Gelgel-1which belongs to El-Wastani Petroleum Company and El-Berka wastewater treatment plant. Some chemical and physical properties of the representative samples are presented in Tables 1 and 2.

Industrial wastewater and sewage water effluent were treated with different rates of more effective microorganism (MEM) 0.5, 1.0, 1.5 g.m^{-3}. Times adjusted at 0.5, 12 and 24 hrs. under different conditions (aerobic and anaerobic). After each incubation period, physical and chemical characteristics of industrial and wastewater treated were determined according to the method described by APHA (1992)

Table (1): Some chemical and physical characteristics and heavy metal contents of industrial wastewater of well gelgl El-Wastani Petroleum Company

pH	EC dSm^{-1}	Physical properties				Chemical properties										
		Density	BOD	COD	DO	Na	K	NH_4	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3	PO_4
		g/em^3	mg/L			meq/L										
7.16	27.1	1.030	258	314	2.98	-	0.14	39.3	33.5	3.0	4.54	7.30	562.5	7.8	14.45	4.13

Heavy metal contents										
Fe	Mn	Zn	Cu	Pb	Cd	Ni	Co	Cr	Mo	B
mg/L										
3.14	2.79	2.28	2.27	2.51	1.23	2. 31	1.93	1.89	1.29	0.89

Table (2): Some chemical and physical properties and heavy metal contents of wastewater of El-Berka plant.

pH	EC dSm^{-1}	TSS	TS	VSS	TVA	TDS	BOD	COD	DO
		mq/L							
7.35	2.65	356	870	263	374	1693	354	660	1.85

Heavy metal contents										
Fe	Mn	Zn	Cu	Pb	Cd	Ni	Co	Cr	Mo	B
mg/L										
15.79	2.48	1.75	2.95	3.39	1.26	7.93	1.59	3.87	1.38	0.93

RESULTS AND DISCUSSION

Bioremediation of industrial wastewater:

Table (3) showed effect of bioremediation of industrial wastewater well Gelgel-1 El-wastani Petroleum Company under different doses of MEM and different aeration and non-aeration conditions. Results revealed that application of MEM at different doses decrease the pH of the wastewater by about 10, 12 and 14% at rate of 0.5, 10 and 1.5 g.m^{-3} MEM, respectively. The reduction in pH of the industrial wastewater may be related to the destruction of organic material creating small molecular of organic acid which minimizes the pH of the global system. It was noticed that aeration condition stimulated the reduction of the pH of the industrial wastewater particularly after 24 hrs. The total reductions in pH of the industrial wastewater were 11, 15, and 19% at rate of 0.5, 10 and 1.5 g.m^{-3} MEM, respectively. Similarly were observed by several researchers (US EPA 1980; Karam and Nicel 1997; Duckworth and Coleman 1976).

Results also indicated that application of more effective microorganisms (MEM) at different rates slightly reduced the electrical conductivity by about 7, 10 and 15% at rates of 0.5, 10 and 1.5 g.m^{-3},respectively particularly, under anaerobic condition. Whiteley et al. (2002) illustrated that enzymes are able to break a part of large organic particles, creating more surface area for microbes to attack. Microorganisms, through their enzymatic pathways, act as biocatalysts and facilitate the progress of biochemical reactions that degrade the targeted contaminants. Bioremediation has been used in the clean-up of organic (e.g., chlorinated solvents, petroleum hydrocarbons, and pesticides), inorganic (e.g., perchlorate and nitrate), metals, and radionuclides contaminated sites (Zhu X et al. 2004:, USEPA, 2013).

It was observed that under aeration condition the effect of MEM was more pronounced effect, percentage of reductions of electrical conductivity were 28, 32 and 40% at rate of 0.5, 10 and 1.5 g.m^{-3} MEM, respectively. The aeration condition can favorable for precipitation some salt during the incubation periods. Results showed that increasing the time of incubation gradually decreased the electrical conductivity.

Industrial wastewater contain considerable amount of mono- ethylene-glycole (MEG), the role of the glycol is to prevent the formation of gas hydrates which could block the pipeline at low flow rates and to acidify of the effluent so as to avoid corrosion and thus, prolong pipeline life.

Application of MEM at different rates and under non-aeration condition gradually, reduced the concentration of the organic compound. Percentages of removal were 41, 44, and 48% at 0.5, 1.0 and 1.5 g.m^{-3}, respectively particularly after 24 hr. of treatment. Results also revealed that aeration condition accelerated the degrability of organic compounds, the percentage of removal were 62, 75 and 92% at rates of 0.5, 10 and 1.5 g.m^{-3} (MEM), respectively. Several researchers USEPA, (2013), Farhadian M. (2008), reported that contaminants at bioremediation sites are degraded through a number of biochemical reactions that include aerobic reactions, anaerobic oxidative reactions, anaerobic reductive reactions, and co-metabolic reactions. Aerobic bioremediation uses molecular oxygen (O2) as an electron acceptor in remediation through direct microbial metabolic oxidation of a contaminant. Aerobic bioremediation is most effective in degrading non-halogenated organic compounds (e.g., BTEX, diesel) to carbon dioxide and water Results revealed that, application of MEM gradually reduced the BOD at different doses and conditions, after one day of treatment, minimum removal of BOD observed in the treatment at rate of 0.5 g.m^{-3} particularly under non-aerobic condition, percentage of removal was 22% Nevertheless, maximum removal (91%) was noticed at 1.5 g.m^{-3} under aerobic condition. Increasing the concentration of MEM, the percentage of removal of *BOD* were gradually increased, by about 22, 37, and 64% at rates of 0.5, 1.0 and 1.5 g.m^{-3}, respectively under non-aeration condition. The percentage of BOD removal gradually increased under aeration condition. Average of removal was 55, 72 and 91% at 0.5, 1.0 and 1.5 g.m^{-3} of *MEM* respectively. Balaji et al. (2005) reported that biological treatment of wastes is a good method for industrial effluents. Treatment of wastes with bacteria involves the stabilization of waste by decomposing them into harmless inorganic solids either by aerobic or anaerobic process.

Bioremediation of industrial wastewater by *MEM* resulted in a reduction of *COD*. Maximum removal of the COD (59%) was obtained at rate of 1.5 g.m^{-3} after 24 hrs. However, minimum removal (28%) was observed at rate of 0.5 g.m^{-3}. Results showed that increasing the aeration condition gradually stimulated the distraction of the organic matter and furthermore reducing the chemical oxygen demand (*COD*).

Table (3): Effect of bioremediation of industrial wastewater by MEM at different rates on physical and chemical properties.

Initial heavy metal			Without aeration									With aeration								
			0.5 g/m^3			1. 0 g/m^3			1. 5 g/m^3			0.5 g/m^3			1. 0 g/m^3			1. 5 g/m^3		
			0.5 hr	12 Hrs	24 Hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs
pH		7.16	7.12	6.89	6.41	7.1	6.7	6.3	6.9	6.5	6.2	7.1	6.8	6.4	7.0	6.9	6.1	6.1	6.4	5.78
EC	$dS.m^{-1}$	27.1	25.61	25.4	25.3	25.1	24.6	24.4	24.8	24.7	23.6	19.7	19.7	19.4	18.7	18.5	18.3	17.7	17.6	16.14
MEG	mg/l	290	231	198	171	212.0	183.0	161.0	193.0	178.0	148.0	13.5	115.0	109.0	93.0	89.0	71.0	60.8	41.7	21.18
Cations meq/l																				
Na	meq/l	66.45	63.3	62.2	59.1	59.8	57.7	57.6	56.5	49.9	48.8	45.4	43.1	42.4	34.3	31.2	29.1	18.3	17.8	14.71
K	meq/l	0.14	0.14	0.13	0.14	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.13
Ca	meq/l	33.5	31.5	29.4	29.3	29.4	28.3	27.2	25.1	20.1	19.1	18.2	15.4	14.8	12.7	11.3	11.2	11.1	10.9	10.18
mg	meq/l	3.5	2.8	2.7	2.6	2.7	2.6	2.5	2.3	2.0	1.9	1.2	1.2	1.2	1.1	1.1	1.0	0.9	0.8	0.73
Anions meq/l																				
CO_3	meq/l	4.5	4.5	4.5	4.5	4.1	4.1	4.1	3.8	3.6	3.5	3.4	3.2	3.1	3.5	3.4	3.3	2.8	2.6	2.5
HCO_3	meq/l	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.1	7.1	7.1	6.9	6.8	6.6	6.4	6.3	6.2	6.2	6.2	6.2
Cl	meq/l	562.5	480.0	473.0	469.0	439.0	431.0	424.0	314.0	289.0	251.0	260.0	243.0	210.0	173.0	127.0	79.3	67.9	67.2	66.4
SO_4	meq/l	7.8	7.4	7.3	7.3	7.2	7.2	7.2	6.9	6.9	6.9	6.8	5.6	5.5	5.3	5.2	5.1	4.9	4.8	4.7
NO_3	meg/l	14.5	9.2	8.7	8.5	8.2	8.2	7.1	7.2	2.1	2.1	4.8	4.6	3.7	2.2	2.2	2.1	1.8	1.2	1.2
NH_4	meg/l	39.3	21.2	17.5	10.1	19.2	13.2	11.2	15.9	3.1	3.1	5.2	3.1	2.1	4.2	3.6	2.4	2.1	1.1	0.8
PO_4	meg/l	4.1	3.6	3.2	2.6	3.2	3.2	2.4	3.2	1.0	0.9	2.1	2.0	1.8	1.5	1.3	1.2	1.2	1.2	0.4
BOD	meg/l	258.0	241.0	212.0	201.0	179.0	178.0	163.0	151.0	123.0	92.0	240.0	212.0	117.0	101.0	99.5	83.3	61.1	53.9	23.9
COD	meg/l	314.0	251.0	243.0	225.0	163.0	153.0	142.0	139.0	131.0	129.0	124.0	123.0	115.0	93.0	83.7	71.9	69.8	61.3	55.9
DO	meg/l	3.0	2.8	2.9	2.9	2.8	2.7	2.6	2.6	2.5	2.5	3.4	3.5	3.5	4.6	4.7	4.8	4.7	4.8	5.2
Density	g/cm3	1.030	1.024	1.030	1.020	1.020	1.021	1.021	1.010	1.004	1.008	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001

Table (4): Effect of bioremediation of industrial wastewater by MEM at different rates on removal of heavy metals.

Initial heavy metal		Without aeration									With aeration								
		0.5 g/m^3			1. 0 g/m^3			1. 5 g/m^3			0.5 g/m^3			1. 0 g/m^3			1. 5 g/ m^3		
		0.5 hrs	12 hrs	24 Hrs	0.5 hr.	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs	0.5 hr	12 hrs	24 hrs
Fe	3.14	2.08	1.69	1.29	2.03	1.41	0.93	1.15	0.98	0.43	1.23	0.92	0.31	1.09	0.79	0.29	1.03	0.58	0.24
Mn	2.79	2.36	2.19	1.89	2.15	1.73	1.01	1.09	0.89	0.54	1.79	1.46	0.73	1.29	0.90	0.56	1.58	0.98	0.38
Zn	2.28	1.97	1.63	1.15	1.83	1.57	1.13	1.64	0.93	0.49	1.89	1.57	0.98	1.73	0.98	0.63	1.69	0.73	0.46
Cu	2.23	2.13	1.79	1.43	1.89	1.61	1.23	1.69	1.13	0.83	1.72	1.48	1.07	1.63	1.10	0.79	1.78	1.10	0.68
Pb	2.51	2.43	1.89	1.61	2.29	1.73	1.09	2.21	1.29	0.89	1.98	1.39	0.94	1.73	1.08	0.63	1.68	1.15	0.53
Cd	1.23	1.18	1.13	1.08	1.12	0.89	0.73	1.13	0.69	0.57	1.09	0.89	0.43	0.98	0.64	0.43	0.83	0.61	0.42
Ni	2.31	2.18	1.72	1.49	2.08	1.78	0.98	1.78	1.31	0.73	1.59	1.13	0.78	1.43	0.71	0.39	0.28	0.78	0.31
Co	1.93	1.61	1.81	1.19	1.47	1.22	0.87	1.32	1.12	0.81	1.28	1.09	0.69	1.15	0.83	0.42	1.10	0.81	0.53
Cr	1.89	1.59	1.32	1.09	1.49	1.22	1.01	1.31	1.09	0.79	1.29	0.99	0.58	1.21	0.89	0.62	1.11	0.98	0.62
Mo	1.29	1.09	0.98	0.71	1.10	0.98	0.72	0.93	0.71	0.63	1.18	0.89	0.49	1.21	1.18	0.69	1.09	0.83	0.57
B	0.89	0.61	0.53	0.49	0.53	0.41	0.31	0.51	0.42	0.39	0.40	0.31	0.29	0.49	0.39	0.24	0.39	0.31	0.21

Table (5): Effect of bioremediation of sewage water effluent by MEM at different rates on physical and chemical properties.

initial value			without aeration									With aeration								
			0.5 g/m³			1. 0 g/ m³			1. 5 g/m³			0.5 g/m³			1. 0 g/m³			1. 5 g/m³		
			0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs
pH		7.35	7.31	7.27	7.18	7.26	7.14	7.09	7.19	7.09	6.91	7.10	7.01	6.65	7.07	7.07	6.21	6.63	6.14	5.85
EC		2.65	2.51	2.43	2.37	2.46	2.39	2.09	2.10	1.89	1.65	1.91	1.73	1.48	1.83	1.67	1.29	1.78	1.27	101
TSS	**mg/l**	356	341	338	3	335	310	298	3	283	271	73	62	51	58	51	48	78	72	24
TS	**mg/l**	870	698	575	543	514	410	385	462	341	289	540	447	413	468	316	215	329	213	181
VSS	**mg/l**	263	247	231	219	238	224	211	239	214	197	237	212	189	178	132	82	141	73	21
TVS	**mg/l**	374	371	316	279	362	303	242	321	193	187	189	169	152	173	153	142	168	145	129
TDS	**mg/l**	1696	1672	1612	1526	1543	1392	1340	1381	1118	1034	1101	981	933	948	879	814	737	649	593
BOD	**mg/l**	354	314	269	212	281	221	189	263	189	164	241	123	81	239	109	49	173	62	23
COD	**mg/l**	660	642	518	409	483	379	321	391	213	149	289	129	78	143	129	63	141	119	48
DO	**mg/l**	1.85	1.79	1.83	1.94	2.14	2.21	2.31	2.19	2.23	2.41	3.79	3.98	4.89	4.97	5.12	5.19	5.10	5.24	5.32

It was observed that increasing the dissolved oxygen (*DO*), gradually reduced the chemical oxygen demand (*COD*). Results showed that percentage of removal was 63, 77 and 82 % at rate of 0.5, 10 and 1.5 g.m^{-3} MEM, respectively.

The presence of phosphorus normally due to the industrial wastewater and atmospheric deposition. This compound may contain 5-20 mg.l^{-1} of the total phosphorus of which 1-5 mg.l^{-1} in organic and the rest is inorganic Ashton (2013), Slgueriro (2016). Table 3 showed that under non-aeration condition application of *MEM* reduced the phosphorus content by about 37, 41, and 78% at rate of 0.5, 10 and 1.5 g.m^{-3} MEM, respectively. Results noticed that under aeration condition , percentages of removal were gradually increased. Average of removal was 56, 71 and 90% at rate of .50, 1.0 and 1.50 g.m^{-3}respectively. The beneficial effect of aeration generally increased the dissolved oxygen which creating oxidative media for minimizing the concentration of organic toxic material. This is clearly observed in non-aeration condition particularly, at low dose of *MEM.* The difference between aeration and non-aeration conditions at low rate for removal is about 50%. Even at all rates, the difference between them was rather low. Such phenomenon may be explained in term of enzymatic inhibition, since high concentration of organic toxic material may minimize the enzymatic reaction particularly at the beginning of bio-treatment. This can be solved by the enzymation pretreatment, which diminishes operational time and improve removed efficiency. This was clearly noticed under aerobic condition. Bevilaqua et al. (2002) observed similar results**.**

Table (4) showed that application of *MEM* at different rates 0.5, 1.0, 1.5g.m^{-3} and under aeration and non-aeration conditions, gradually decreased heavy metal contents. Results indicated that percentages of removal of Fe under non-aeration condition were 59, 70 and 86% after 24 hrs of incubation. However, under aeration condition, the percentage of removal was 90, 91 and 92% at rates of 0.5, 1.0 and 1.5 g.m^{-3}, respectively. It was also noticed that the percentage of removal of Mn was 32, 64 and 81% and 74, 80 and 86% under non-aeration and aeration condition respectively. Aeration condition stimulated the removal of both elements, since both the two elements were affected by oxidation-reduction condition. Several different physicochemical and biological processes are commonly employed to remove heavy metals from industrial wastewaters before their discharge into the environment (Fomina and Gadd 2014).

Conventional physicochemical methods such as electrochemical treatment, ion exchange, precipitation, osmosis, evaporation, and sorption are not cost-effective, and some of them are not environmentally friendly Mulligan et al. (2001). On the other hand, bioremediation processes show-promising results for the removal of metals, even when present in very low concentrations where physicochemical removal methods fail to operate. Furthermore, this is an eco-compatible and economically feasible option. Bioremediation strategy is based on the high metal binding capacity of biological agents, which can remove heavy metals from contaminated sites with high efficiency. In this regard, microorganisms can be considered as a biological tool for metal removal because they can be used to concentrate, remove, and recover heavy metals from contaminated aquatic environments Riggle et al. (2000)

Results in Table 4 also, showed that bioremediation of industrial wastewater gradually reduced the investigated heavy metal contents. By increasing the rate of *MEM,* the removal of heavy metals increased and gradually stimulated under aeration as compared with non-aeration condition.

Chaalal et al. (2005) reported that chemical precipitation, chemical oxidation and reduction, ion exchange, filtration, electrochemical treatment, reverse osmosis and solvent extraction are the most commonly used techniques for the removing of heavy metals ions from dilute solutions. Furthermore, these techniques of purification are often inappropriate or expensive, particularly when unwanted heavy metals are present in very low concentration or in large solution volume.

Bioremediation of wastewater effluents:

Table (5) showed the effect of bioremediation of wastewater effluent under different doses of *MEM* (0.5, 1.0 and 1.5 g.m^{-3}) and conditions on the chemical and physical properties of wastewater effluent. Results revealed that application of *MEM* at different doses slightly decreased the pH of sewage effluent particularly after 24 hrs. Average of decreases were 2, 4 and 6% at 0.5, 1.0 and 1.5 g.m^{-3} particularly under non-aeration condition, respectively. It was noticed that aeration condition gradually reduced the pH of the wastewater effluent. This phenomenon may be explained by the degrability of the organic matter, since the destruction of the organic matter to smaller part, creating the lowering pH of the sewage effluents. Results also

Table (6): Effect of bioremediation of sewage water effluent by MEM at different rates on removal of heavy metals.

Initial heavy metal		Without aeration									With aeration								
		0.5 g/ m^3			1. 0 g/ m^3			1. 5 g/ m^3			0.5 g/ m^3			1. 0 g/m^3			1. 5 g/m^3		
		0.5 hrs	12 hrs	24 hrs.	0.5 hrs.	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs	0.5 hrs	12 hrs	24 hrs
Fe	15.79	8.13	6.11	2.89	6.73	5.09	1.64	5.47	3.14	1.48	5.66	3.16	2.48	4.78	2.93	1.01	3.92	1.24	0.81
Mn	2.48	2.39	2.14	1.79	2.17	1.98	1.62	1.98	1.42	1.02	2.25	1.93	1.42	2.18	1.71	1.15	1.93	1.41	0.91
Zn	1.75	9.61	7.71	2.14	9.41	5.14	1.72	6.91	5.11	1.14	6.81	2.11	1.36	5.42	3.11	1.18	5.11	2.42	1.01
Cu	2.95	2.61	2.42	1.98	2.53	2.19	1.63	2.48	1.98	1.09	2.18	1.46	1.12	1.81	1.13	0.98	1.62	1.23	0.89
Pb	3.39	3.21	2.89	1.78	3.09	1.68	1.31	2.78	1.98	1.15	2.51	1.67	1.10	2.32	1.19	0.83	2.18	1.45	0.79
Cd	1.26	1.19	1.09	0.91	1.12	0.98	0.83	1.09	0.88	0.69	1.18	1.09	0.79	1.10	0.93	0.62	0.98	0.63	0.41
Ni	7.93	7.13	5.41	1.98	6.16	3.78	1.24	5.71	2.14	1.04	5.61	2.14	1.18	4.98	3.14	0.98	4.79	2.10	0.83
Co	1.59	1.39	1.98	1.01	1.32	1.79	0.89	1.31	1.45	0.97	1.41	1.01	0.54	1.22	0.89	0.49	1.09	0.78	0.39
Cr	3.87	3.61	2.98	1.21	3.48	1.59	1.12	3.14	1.35	0.99	3.00	1.47	1.01	2.89	1.23	0.92	2.64	0.87	0.6
Mo	1.38	1.31	1.15	1.08	1.28	1.10	0.98	1.25	0.89	0.63	1.29	1.09	0.81	1.18	0.93	0.78	1.10	0.81	0.68

Revealed that aeration condition accelerated the reduction of pH; average of decreases was 10, 16 and 21%. Chandrasekaran and Rajkannan (2003) reported that increasing the dissolved oxygen (*DO*) through aeration processed may enhanced either the destruction of the organic material to form organic acids or increasing the growth of the microorganisms, both two processes may reduce the acidity of sewage effluents.

Results revealed that application of MEM reduced the electrical conductivity (EC). It was noticed that at all rates of *MEM* the reduction of *EC* of the sewage effluents were observed. Average of decreases was 11, 21 and 38% at 0.5, 1.0 and 1.5 $g.m^{-3}$ under non-aeration condition, respectively. However, under aeration, considerable reductions were recorded. Averages of reductions were 44, 51, and 62% of the previous treatment; respectively.

It was also observed that total suspended solids (TSS) were gradually affected by the bio-treatment. Application of MEM gradually reduced the total suspended solids. Averages of removal were 7, 16 and 24% at 0.5, 1.0 and 1.5 $g.m^{-3}$, respectively. Under aerobic condition, reduced the total suspended solids gradually decreased as compared with non-aeration condition. Results showed that percentage of removals were 86, 87 and 93% at 0.5, 1.0 and 1.5 $g.m^{-3}$ respectively. Gianfreda and Rao (2004) stated that enzymatic reaction could transform a compound from contrary state to one that is more biodegradable. In other cases, extra cellular enzymes are able to increase the degradation rate of already biodegradable substances, such as activated organic materials (Sludge) throughout the oxidative media allowing for more efficient treatment processes. Similar results were reported by Whitely et al. (2002). Marcosede Monte et al. (1989). Under anaerobic condition, results showed that percentage of removed of *BOD* were 40, 47 and 54% particularly, after 24 hr. of incubation and different rates of *MEM* 0.5, 1.0 and 1.5 $g.m^{-3}$, respectively. Whereas, under aeration condition significantly decreased of biological oxygen demand (*BOD*) and averages of removal were 77, 86 and 94% at 0.5, 1.0 and 1.5 $g.m^{-3}$, respectively. Aeration may enhance the growth of microbial and furthermore reduced the *BOD*. Averages of removal under aeration condition were 92, 80 and 74% as compared to the non-aeration circumstances. Similar were noticed in case of *COD*, but aeration condition stimulates the removal percentage of *COD* by about 88, 90 and 93% as compared to the non-aeration condition.

Table (6) showed that the beneficial effect of (MEM) as bioremediation on the initial heavy metal contents in sewage effluents. Result revealed that application of *MEM* at different rates 0.5, 1.0 and 1.5 g/m^3 gradually decreased the Fe and Mn. Data showed that the percentages of removal of both iron and manganese were 82, 90, 91% and 28, 35 and 59% particularly, under anaerobic condition, and at different rates of *MEM* 0.5, 1.0 and 1.5 g/m^3 respectively and after 24 hr. of incubation. Results also revealed that higher percentages of removal of both elements were noticed under aeration condition 84, 94, 95% and 43, 54 and 63% at the same rates and after one day of treatment.

Results also showed that increasing the rate of MEM from 0.5 to 1.5 g.m^{-3} resulted in a remarkable decreased of the investigated elements. These fractions were gradually decreased based on the mechanical oxidation, which enhanced the percentage of heavy metals removal particularly under aeration circumstances

Sewage effluent of El-Berka sewage water plant contained low concentration of heavy metal, due to the restriction of the environmental law. Means that sewage effluent contains less amount of industrial effluent or even treated industrial effluent. Table (6) showed that low rate of more effective microorganisms (*MEM*) can be efficient used to remove the heavy metal contents in sewage water effluent. Balaji et al. (2005) reported that fundamental process of aerobic decomposition of organic remains unchanged from system to system. Biological treatment of wastewater has numerous advantages over other treatment methods in terms of time and cost saving. They also stated that it gives the appreciable performance in the removal of non-nutritive heavy metals.

CONCLUSION

Application of *MEM* of industrial waste water effluent stimulated the reduction of the investigated heavy metals. Further research must be done before this technology can be used on a wide scale.

CONFLICT OF INTEREST

The authors declared that there was no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the experiments AMA preformed the experimental work, YAA and AEAA carried out laboratory and statics analysis. AMA and AEAA wrote the manuscript, all authors revised and approval the final version.

Copyrights: © 2017 @ author (s).

This is an open access article distributed under the terms of the **Creative Commons Attribution License (CC BY 4.0)**, which permits unrestricted use, distribution, and reproduction in any medium, prvided the original author(s) and source are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

REFERENCES

Al-Baldawi, I.A.; Sheikh Abdullah, S.R.; Anuar, N.; Suja, F. and Mushrifah, I. (2015): Phytodegradation of total petroleum hydrocarbon (TPH) in dieselcontaminated water using Scirpus grossus. Ecol. Eng., 74: 463–473.

Alwan, A.H.; Fadil, S.M.; Khadair, S.H.; Haloub, A.A.; Mohammed, D.B.; Salah, M.F.; Sabbar, S.S.; Mousa, N.K. and Salah, Z.A. (2013): Bioremediation of the water contaminated by waste of hydrocarbon by use Ceratophyllaceae and Potamogetonaceae plants. J. Genet. Environ. Resour. Conserv., 1(2):106–110

APHA (1992) Standard methods for the examination of water and wastewater, 18th ed., American Public Health Association, Maryland. Application. Bio resource Technology 2014; 160 3–14.

Arar A. L. (1988) Water management and conservation measures under semi-arid and arid condition in : optimization of water in agriculture, proceeding of the regional Seminar; Amman, Jordan 21-24, p. 177.

Ashton Q. (2013) Phosphoric acids – Advances in research and application: 2013 Edition(Scholarly Brief. Scholarly Edition)

Balaji V,S. Datta and C. Bhattacharjee (2005) Evaluation on Biological Treatment for industrial waster water. IE (1) Jornal-CH. Vol. 85.

Chaalal Omar, Adulrazag Y., Zekri and Rafig Islam (2005). Uptake of heavy metals by microorganisms: An Experimental approach. Energy sources, 27 L 87-100.

Chandrasekaran, N. and B. Rajkannan (2003). Nature and charaateristics of sewage effluents of tamil Nadu. Madras Agric J. 90 (1-3): 124-128.

Coulon, F.; Whelan, M.J.; Paton, G.I.; Semple, K.T.;Villa, R. and Pollard, S.J.T. (2010):

Multimedia fate of petroleum hydrocarbons in the soil: Oil matrix of constructed biopiles. Chemosphere, 81(11): 1454–1462.

Dell'Anno, A.; Beolchini, F.; Rocchetti, L.; Luna, G.M. and Danovaro, R. (2012): High bacterial biodiversity increases degradation performance of hydrocarbons during bioremediation of contaminated harbor marine sediments. Environ. Pollut., 167: 85–92.

Dellagnezze, B.M., de Sousa, G.V., Martins, L.L., Domingos, D.F., Limache, E.E.G., de Vasconcellos, S.P., da Cruz, G.F., de Oliveira, V.M., 2014. Bioremediation potential of microorganisms derived from petroleum reservoirs. Mar. Pollut. Bull. 89, 191e200

Duck Worth, H. and Coleman (1976). Physicochemical and kinetic properties of Mushroom Tyrosinase, J. boil. Chem.. 245, 1613-1625.

Fomina M., Gadd G. M. Biosorption: current perspectives on concept, definition and

Fullbrook, P.D. (1996) "Kinetics" Industrial Enzymology: the Application of Enzymes in Industry. 2nd Ed. T. Godfrey and Reichelt, eds. Nature. New York.

Gaspare, L.; Machiwa, J.F.; Mdachi, S.J.M.; Streck, G and Brack, W. (2009): Polycyclic aromatic hydrocarbon (PAH) contamination of surf acesediments and oysters from the inter-tidal areas of Dares Salaam, Tanzania. Environ. Pollut., 157(1):24–34.

Gianfreda, L. and Rao, M.A. (2004) Potential of extra cellular enzymes in remediation: A review". Enzyme Microb. Technol., 35, 339-354.

Gomez, F. and Sartaj, M. (2014): Optimization of field scale biopiles for bioremediation of petroleum hydrocarbon contaminated soil at low temperature conditions by response surface methodology (RSM). Int. Biodeterior. Biodegradation, 89: 103–109

Hassanshahian, M., Emtiazi, G., Caruso, G., Cappello, S., 2014. Bioremediation (bioaugmentation/biostimulation) trials of oil polluted seawater: a mesocosm simulation study. Mar. Environ. Res. 95, 28e38

Huang Y, Wong C, Zheng J, Bouwman H, Barra R, Wahlstrom B, Neretin L, Wong M (2012) Bisphenol A (BPA) in China: a review of sources, environmental levels and potential human health impacts. Environ Int 42:91–99.

Karam, J. and Nicel, M.A., (1997). Potential application of enzymes in waste water treatment. J. chem.. Tech. Biotechnol. 69, 141-153.

Kumar, D., Rai, J., Gaur, J.P., 2012. Removal of metal ions by Phormidium bigranulatum (Cyanobacteria)-dominated mat in batch and continuous flow systems. Bioresour. Technol. 104, 202–20.

Kumar, D., Rai, J., Gaur, J.P., 2012. Removal of metal ions by Phormidium bigranulatum (Cyanobacteria)-dominated mat in batch and continuous flow systems. Bioresour. Technol. 104, 202–20

Lessinger, A.M, Cook, N.J and Hutter, R (1996) Microbial degradation of Xenobiotics and Recalitrant compound, Academic Press, London.

Lopez, A., Pollice, A., Lonigro, A., Masi, S., Palese, A.M., Cirelli, G.L., Toscano, A., Pasino, R. 2006. Agricultural wastewater reuse in southern Italy. Desalination 187, 323–334.

Mates JM, Segura JA, Alonso FJ, Marquez J (2010) Roles of dioxins and heavy metals in cancer and neurological diseases using ROS-mediated mechanisms. Free Radic Biol Med 49:1328–1341.

Mulligan C. N., Yong R., Gibbs B. F. (2001). Remediation technologies for metal contaminated soils and groundwater: an evaluation. Engineering Geology 60 (1–4) 193– 207.

Riggle P. J., Kumamoto C. A., (2000) .Role of a Candida albicans P1-type ATPase in resistance to copper and silver ion toxicity. Journal of Bacteriology; 182 - 4899–4905

Rubino, P., Lonigro, A. 2008. Municipal treated wastewater irrigation. Microbiological risk evaluation. Ital. J. Agron. 2, 119–124.

Salgueiro,j.l.,Perez,L.,Maceiras,R,Sanchez and Cancela,A.(2016) Bioremediation of wastewater using chlorella vulgaris microalgae: phosphorus and organic matter.Int.J.Environ.Res.10(3):465-470,

US EPA. (1980) Treatability Manual, Vol. 1 – Treabability Data U.S. Environmental protection Agency Washington D.C.

USEPA, 2013. Introduction to in situ bioremediation of groundwater. Office of Solid

Vivaldi, G.A., Camposeo, S., Rubino, P., Lonigro, A. 2013. Microbial impact of different types of municipal wastewaters used to irrigate nectarines in southern Italy. Agricult. Ecosys. Environ. 181, 50–57.

Water and Emergency Response, EPA542-R-13-018.

Whiteley, C. G., Heron, P., Pletschke, B., Rose, P.D., Tshivhunge, S., Van Jaarsveld, F.P., Whitington-Jones, K. (2002). "The enzymology of sludge solubilization utilizing sulphate reducing systems: The properties of protease and phosphatases". Enzyme Microb. Technol. 31, 419-424.

Wu, Q., You, R., Clark, M., and Yu, Y. (2014). “Pb (II) removal from aqueous solution by a low-cost adsorbent dry desulfurization slag.” Appl. Surf. Sci., 314, 129–137.

Zhu X, Venosa AD, and Suidan MT (2004). Literature review on the use of commercial bioremediation agents for cleanup of oil-contaminated estuarine environment. EPA/600/ R-04/075.