World Journal of Environmental Biosciences

Available Online at: **www.environmentaljournals.org**

Volume7, Issue 3: 74-80

ISSN 2277- 8047

Treatment of Polluted Water of Asaluyeh Petrochemical Units Using Activated Sludge Method

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ABSTRACT

This study aims to treat polluted waters of Asaluyeh petrochemical units using activated sludge method. In this method the qualitative and quantitative analyses were conducted on chemical and biological sludge samples besides ashes resulted from burned sludge. Then, in order to determine an optimal usage of chemical and biological sludge, different approaches were studied, and the most appropriate one, which has technical and economical justifications, was introduced and finally, efforts were made for marketing and communicating with sludge and ash consumer industries. The results of this study showed that because of relatively high humidity of these sludge which requires heat for evaporation, the burning process of the sludge is an expensive method. Also, organic materials comprise a major part of chemical and biological sludge, which considerably decrease after turning into ashes because of burning organic materials and their conversion to gases. Among metal oxides in these three types of chemical and biological sludge and ashes, the iron oxides are the main ones. Our analysis of these ashes and sludge showed that this sludge can be used in order to enhance mechanical resistance in asphalts due to their high organic load index LOI in addition to the presence of silicon and aluminum oxide. The obtained ashes and biological sludge have the capacity to be used as chemical fertilizers in pastures and agricultural lands. The ashes resulted from burning chemical and biological sludge in Mobin petrochemical complex have the capacity to be used in bricks.

Keywords: *Petrochemical Treatment, Chemical Sludge, Biological Sludge and Ashes Resulted from Burning the Sludge.*

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Received: 28 January 2018
Accepted: 23 July 2018

1. INTRODUCTION

Almost all countries of the world are committed to try hard and preserve the environment and this planet for next generations. One of these commitments is to preserve water resources and establish wastewater refining plant to treat polluted waters, which should be carried out based on a certain schedule.

In addition to the distribution of different diseases, water pollution also affects the health and quality of limited water resources, and in long-term, is able to socially and economically damage the society. In return, not only using appropriate treatment methods will improve the health of the society, but by recovery and use of refined sewage, it is also possible to compensate a little for drought. (E. Vgetti et al, 2009). Accordingly, recycling wastewaters and refined industrial wastewaters, is significantly important, especially in dry and waterless countries. This method attracts attention in Iran, and most industries of our country try to recover and refine industrial wastewaters in order to improve their products and creating an environment to flourish and prosper. Basically, one of the most important aspects in sustainable development of industry is to prevent pollution resulted from industrial activities (especially industrial wastewaters) and wastewater treatment by use of a proper method with the acceptable standard in order to recycle and reuse water. In case of keeping raw wastewater, its organic materials will break down and produce smelly gas. Furthermore, untreated wastewater contains virulence microorganisms which inhabit in human's gastrointestinal tract or industrial wastes. (Chung-Sun E. Road, Chungli, 2006).

Wastewaters also have toxics and organic nutrients which are able to induce aquatic plant growth and development. Therefore, a quick and flawless collection of wastewaters (in case of treatment and excretion and production sources), is not only favorable but also critical for industrial societies. Hence, providing a healthy environment for the people, keeping the environment clean, and recycling the wastewaters are the aims of wastewater treatment. (M. A. Abduli et al, 2006).

The Mobin petrochemical wastewater unit designed based on removing organic, non-organic and mineral materials. Generally, this unit uses physical, chemical and biological methods to remove pollutants and mineral salts. Those waters which were directed to Mobin petrochemical wastewater unit came from petrochemical companies like Zagros, Jam, Mobin, Borzuyeh, Arya Sasol, Pars, Ghadir, and rainwaters of their company area. In this research, at first, the composition of chemical and biological sludge, and the ash of those sludge were studied and qualitatively and quantitatively analyzed, and then appropriate approaches is considered to investigate the best possible industrial use of the sludge (resulted from wastewater treatment) and produced ashes (obtained by burning the sludge).

2. RESEARCH BACKGROUND

Industrial and petrochemical wastes

Industrial wastes need environmentally serious attention due to the possible existence of chemical and toxic compounds and materials which is produced in different stages of production. In petrochemical industries, due to different petrochemical and chemical production units in wastewater treatment unit, a vast range of environmental pollutants like polyaromatic hydrocarbons, heavy metals, and other pollutants will be formed which are able to result in so many different problems for our societies. (M. J. Martin et al, 2003). But, sometimes recycling and reuse of some of these compound is able to not only alleviate their pollution effects but also is economically beneficial. Since the wastewater treatment system in Mobin petrochemical complex is based on biologic treatment through activated sludge, the majority of these materials and pollutants is accumulated in the resulted sludge from the wastewater system. It worth mentioning that the input wastewater of Jam, Arya Sasol, Borzuyeh, Ghadir, Pars, and Zagros enters as wastewater. (Wiebusch and Seyfried, 1977).
In order to clarify the functional dimensions of this company and its key role in preserving the environment of the region, a mass equilibrium in which the circulatory volume of the materials is observed, as shown in below figure (Deng-Fong Lin, Chih-Huang Weng, 2002).

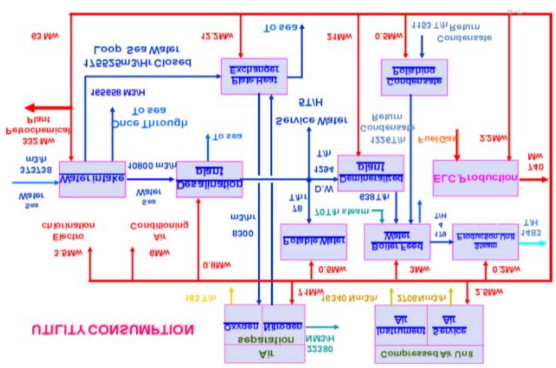

Figure 1: general equilibrium of inputs and outputs of Mobin petrochemical co.

The activated sludge method

Microorganisms in aerating tanks convert organic materials to microbial biomass CO2, and convert organic nitrogen to ammonia or nitrate ions. Microbial cell mass which their production is a part of the treatment process is kept in aerating tanks so that the microorganisms cross the log phase of their growth (Chih-Huang, 2003). At this point, the cells were coagulated and convert to sediment solid particles. This solid particle leads to sedimentation in a sedimentation tank. Some parts of this sediment will be discarded and the other ones will be returned to aerating tank as comeback sludge and came in touch with new wastewater. Mixing so many "hungry" cells from comeback sludge which nutrient source of raw wastewater, provide the best situation for a quick breakdown of organic materials. (Joo-Hwa, Woon-Kwong, 1989).
The activated sludge method provides two pathways to remove BOD. BOD removal can be done either by oxidation of organic materials in order to provide the energy required for metabolic processes of the microorganisms, or by using organic materials in the structure of new cells. At the first pathway, the carbon exits the tank medium as CO2 gas, and in the second pathway it exists as a solid matter and the mass of the cells will be removed after entering the environment. (G. Tulay et al, 2007). That part of the carbon which turned into CO2, is discharged to the atmosphere and there is no problem for its release, but, releasing the sludge resulted from wastewater is an intricate problem because it contains the only %1 solid materials and contains so many undesirable compounds. Usually, some amount of water in the sludge is separated through filtration drying on sand filters. The dehydrated sludge can be either burned or buried underground. This sludge can be digested to a certain extent and produce methane and CO2. (Craig and Dan, 1987).
Carrying out this process reduces the volume of the sludge and volatile amounts approximately %60. An elaborate system is capable of providing enough energy for a system through this fuel.

Table 1 : the input properties and flow rate to Mobin Wastewater unit

STREM	Design Basis –Maximum Normal Operation						Hydraulic design
	Flow m3/hr	BOD Kg/d	COD Kg/d	OIL Kg/d	TSS Kg/d	TDS Kg/d	Flow m3/hr
COC Water	331	3505	10023	556	726	516948	425
POC Water	125	273	432	288	576	576	200
Sanitary Water	17	71	143	-	61	82	60

The steps of chemical and physical treatment in petrochemical units

The Mobin petrochemical unit has two treatment lines:
1- The first line of COC wastewater and sanitary wastewater by biological and physical and chemical treatment and the sanitary wastewater is added after physical treatment as a nutrient to the biological section. Wastewater treatment which flows to COC unit is refined by following steps:

1. Holding large particles by dirt mesh
2. Separating oils by API
3. Homogenizing or balancing and neutralization
4. Neutralization and flocculation and coagulation and floating
5. Addition of nutrients and biological treatment and clarifying
6. Filtration and passing through active carbon
7. Sludge treatment

2- The second line, is POC sludge. Which only contains physical and chemical treatment, and after that, it will be mixed with COC refine wastewater, and passes through it for the second treatment including filtration and active carbon.
One of the treatment steps in Mobin petrochemical unit which is carried out at the first line of COC wastewater and the sanitary wastewater is homogenizing or balancing and neutralization. At this step, the polluted waters of COC units enter the pond or Tank (50-TK121A/B) in which it completely mixed by the aerators (Mixers 50-MX-122 A-D). Generally, this pond is designed for:

1. Shock preventing on biological systems by through homogenizing pollution load
2. Minimizing chemicals consumption for neutralization

3. Preventing toxics leak with high concentration to biological systems
4. Minimizing biological and chemical-physical treatment flow turbulence, and providing a fixed flow rate of chemical nurturing with the facilities

In the next step, in the first line of COC and sanitary wastewater, neutralization and coagulation and floating and flocculation will be performed. In (50-TK-131A/B) tank, NaOH and H2SO4 will be used and mixed together with the (50-MX-132A/B) mixers in order to adjust pH. Since the bacteria are sensitive to pH, therefore the pH of the wastewater is determined by AIT-1272 and AIT-1252 analyzers and adjusted in the range of 6.5 to 8.5 by commands of 50P-313A/B, 333A/B, 313 B/D, 333 B/F. After pH adjustment, the wastewater is directed to the 50-TK-133A/B tank.

The next step is flocculation and coagulation. After adjusting the pH and entering 50-TK-133A/B tank, chemicals like $FeCl_3$ (ferric chloride) and poly electric (polymer) are injected into the tank and mixed by 50-MX-134A/B mixers. At this step, the flocculation process will be carried out which is known as coagulation. The coagulation is a process in which the small particles came together and make a new big one, sedimentation of which will be a swift and wise-speeded process. One of the important factors for coagulation, is the presence of solid materials or TDS in wastewater, the more TDS content, the better the coagulation process. Another factor is Calcium ions. Calcium ions help coagulation better than sodium ions. Another factor is the temperature, which lower ones prevent coagulation and the range of 30-32 is an adequate temperature for different coagulation. pH is another factor; it should be higher than 4 which is controlled in the range of 6.5 to 8.5.

The next step is floating. After coagulation and flocculation, the wastewater enters the floating pond (50-TK-141A/B) with its own Debi. This pond is known as DAF, which is equipped with 50-X-142A/B and scraper. One of them collect floor sludge and the other one collect sludge at the bottom of the pond and direct them to sludge pond (50-TK-143). The overload sludge of the output is divided into a given reversal ratio, one of which is returned to the 50-TK-1462 tank in a reverse direct and form a mixture of water and air to the DAF system, in which the air is injected by a 50-Cloud computing-135 A/B/C/D compressor in 50-X-138A/B mixing tube. Water to air ratio of 50:50 injected in the 50-D-137A/B vessel by a line series to the beneath of the pond or tank (50-TK-141A/B). Produced bubbles direct small particles to the surface. The sludge is collected and the water overload is directed to aerating tanks from floating pond.

The 5th step of the first line of COC sludge and sanitary wastewater is to add nutrients and biological treatment and clarifying. At the input of (50-TK-160) tank, the sanitary wastewaters and nutrients which include nitrogen (urea) and phosphorus (H3PO4) are injected by (50-P-186A/B) pumps, and final pH is adjusted to 6.5 to 8.5. NaOH is injected by 50-P-333D/F which is controlled by AIT. The temperature is controlled at 30to 32 by vapor injecting. Then the polluted waters enter aerating ponds (50-TK-161A/B) in which aerating is carried out by six compressors (50-C-A/B/C/D/E/F). The soluble oxygen rate in wastewater (DO) should be around 2 PPM. These aerators control the injected oxygen rate to the pond though AIT-1611-1612,1614 for 50-TK-161A, and AIT 1621,1622,1624 for 50-TK-161B, the biological system of this unit is activated sludge system because it contains the bacteria and their metabolism and reproduction. After enough retaining time, the wastewater enters line 1 and comes to sedimentation pond (50-TK-171A/B) and based on the Debi, the sludge will be sediment and the clear wastewater will be overflown. The sediment sludge will be sent to the sludge waste pond and a portion of which will be transferred to aerating sludge pond in order to keep it steady and to provide required sludge for the biological systems. The refined water enters tank (50-TK-173) and is directed to COC filtration by two pumps (50-P-180 A/B). A portion of it will be used to eliminate the foam by spraying it on the surface of aerating pond by a pump (50-P-179A/B).

So, generally the input wastewater which is transferred to the Mobin petrochemical complex, is directed to DAF reservoir, and after coagulation and flocculation and addition of chemicals like ferric chloride and polyelectrolytes, the pollution is transformed into a flock, and at the end it is collected as a chemical sludge from those reservoirs in order to burn them afterwards. These steps are shown in figure 2.

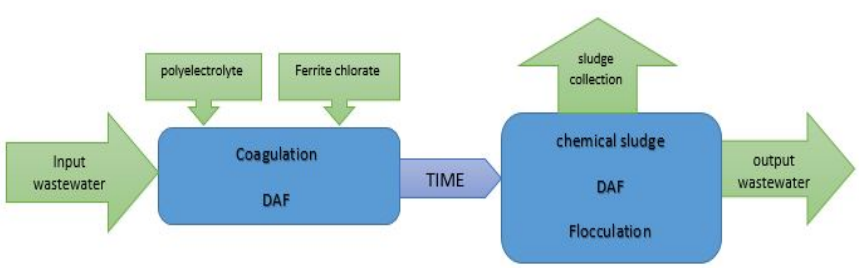

Figure 2: wastewater primary treatment steps

The industrial wastewater is mixed with sanitary wastewater in three reservoirs after exiting the DAF (chemical sludge formation). This sanitary wastewater acts as a nourishment for microorganisms. In this step, the wastewater is aerated. There is also some spray at the top of the reservoirs, which prevent further problems in case of foaming. Here, the DO solution is approximately 5.5 and the pH is 6.5.

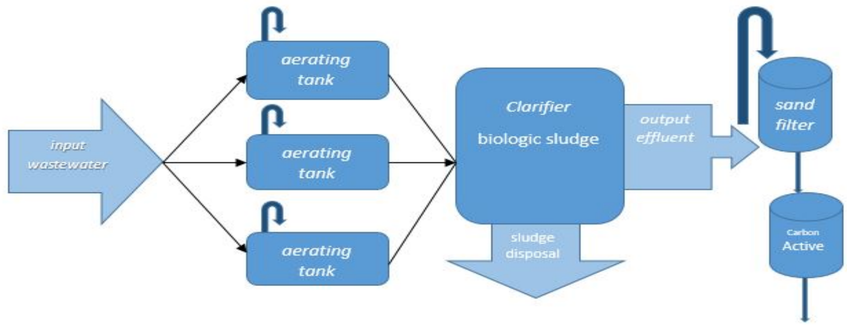

Figure 3: the secondary steps in wastewater treatment

The usable materials from industrial sludge

Using industrial sludge in cement production process is one of the best approaches to solve this problem. This method which is carried out and implemented in some industrial countries like U.S., Canada, and some European countries, not only fixate the heavy metals in a concrete structure, but also prevent any sort of environmental consequences. The thermal content of petroleum sludge can be used to provide part of the fuel required for cement production.

In order to present some approaches to use chemical, biological sludge and the ashes, the industrially usable materials which can be introduced to Mobin petrochemical complex, includes :

1. Using sludge and ash in cement
2. Using ash in asphalt and road construction industries
3. Using ash in brick manufacturing
4. Using sludge in fertilizer manufacturing
5. Solidification and fixation of heavy metal containing sludge in ceramic granules

The aims of the study

a) By using the similar indoor and foreign experiences, and also the pilot experiments, it is possible to offer some approaches in order to recycle and use sources originated from the sludge and the ash
b) The best method(s) which offer more acceptable results in comparison with other ones, will be introduced and the optimal circumstances for their implementation will be determined.

The methodology of this research

In this research, after investigating the performed operations in Mobin petrochemical complex, and a transient look at the operation unit and products of other petrochemical complexes in the region, the identification of materials which presents in the biological and chemical sludge in addition to ashes obtained from burning the wastes, and finally investigating different methods for recycling and using these materials, were set as the aims of this project. In order to conduct the required experiments and analysis of this project, the biological and chemical sludge and the resulted ash from waste burn site in three different time period (2011, 2011 and 2012) of the Mobin petrochemical complex were used as samples. In this research, we use water content evaluation experiments, XRF analysis and heavy metal analysis by atomic absorption.

3. DATA ANALYSIS

1. Water content evaluation

As it can be seen, the water content of chemical and biological sludge is %67 and %82 respectively, which is an indication of high water content in these sludge even after the dehydration process. It was expected that the water content of the ash would be very low, which was otherwise (approximately %18). It may be because of the non-optimal function of the waste burners or mixing the resulted ash (after exiting the waste burner) with that soil of the area. It should be mentioned that water content evaluation for ash and sludge samples in three different time period were performed with three replicate per each time.

Table 2: water content percentage in ash and sludge samples of mobin petrochemical co.

Sample type	Water content (%)
Chemical sludge	%72 ± %5
Biological sludge	%83 ± %3
Ash	%16/2 ± %1/5

2. XRF analysis

In the tables 3 and 4, the results of XRF analysis for chemical sludge, biological sludge, and the ash resulted from the waste burner is shown.

Table 3: the results of XRF analysis for ash samples from Mobin petrochemical complex

Type of the oxide	Weigh percent
(organic material index) L.O.I	23.5
Fe2O3	30.4
Sio2	28.1
Al2O3	16.6
P2O5	12.1
Cao	5.61
K2O	2.34
MgO	1.4
ZnO	0.76
MnO	0.26
So3	0.24
Cr2O3	0.08
Sro	0.064
SnO2	0.045
CuO	0.044
Cl	0.018
V2O5	0.014

Co3O4	0.016
NiO	0.012
Ga2O3	0.004
Rb2O	0.0016

Table 4: XRF analysis of chemical sludge of Mobin petrochemical complex

Oxide type	Weight percent
L.O.I	.21
Fe2O3	28.4
Sio2	12.7
Al2O3	9.6
P2O5	5.3
Cao	3.3
K2O	1.85
MgO	0.72
ZnO	0.122
Cl	0.118
MnO	0.094
SnO2	0.038
Cr2O3	0.035
CuO	0.021
PbO	0.018
Co3O4	0.011
V2O5	0.01
SrO	0.0099
BaO	0.008
NiO	0.0077
ZrO2	0.0013
Ga2O3	-

Table 5: XRF analysis of biological sludge of Mobin petrochemical complex

Oxide type	Weight percent
L.O.I	40.8
Fe2O3	26.1
Sio2	15.1
Al2O3	9.8
P2O5	4.3
MgO	2.7
ZnO	1.22
K2O	1.08
Cao	0.33
Cl	0.115
MnO	0.073
SnO2	0.033
Cr2O3	0.025
CuO	0.022
PbO	0.017
V2O5	0.009
MoO3	0.009
SrO	0.0047
NiO	0.003
Br	0.0012
Rb2O	0.0011
Co3O4	-
Ga2O3	-
Rb2O	-
ZrO2	-

Based on the results of the tables, it can be seen that the iron content in these samples is higher than other compounds, which can be a consequence of the high use of coagulators in flocculation and coagulation steps.

Also, organic material contents which are shown as organic rate index LOI (Loss On Ignition) in these tables, is almost at the same level for chemical and biological sludge (% 40/21 and % 40.8, respectively).

In biological sludge, the SiO2 and Al2O3 is the most abundant metal (% 15.1 and % 9.8, respectively), after iron (%26.1). In the same way, in chemical sludge, the iron (% 28.4) is the most abundant metal, and the silicon oxides and aluminum oxides (% 12.7 and %9.6 respectively) are the most compounds in the sludge after iron.

It is expected that by adding the number of metal oxides like iron oxides, aluminum oxides and manganese oxides and … for chemical and biological sludge, we could be able to find the number of oxides in the ash samples. We compare the above tables and didn't reach to the predicted results; it can be due to heterogeneous input sludge to waster burners in different times.

Generally, and by analyzing these samples, it can be found that the toxicity rate of the sludge and ash is low due to the lower amount of heavy metals like chrome, nickel, cobalt and …, so the possibility of their recycling and converting them to other stuff, is high.

3. Analyzing heavy metals by XRF

Table 6 showed the results of metal evaluation and analysis presented in ash samples of two different time periods. As it can be seen, the iron is the most abundant metal and after that is the manganese, which is an indication of the higher use of their catalysts in petrochemical industries of the region, or high use of iron content coagulators in wastewater treatment system.

Table 6 : analysis of metals in ash resulted from burning sludge in waste burner by atomic absorption

row	Metal	Concentration 1 (ppm)	Concentration2 (ppm)
1	Fe	15100	18500
2	Mn	1070	962 . 5
3	Cu	283/2	241. 05
4	Cr	235/9	158 . 8
5	Ni	148/9	138
6	Vd	46/7	-----
7	Ld	40	46
8	As	31/24	-----
9	Co	22/9	0.1>
10	Hg	13	0.1>
11	Cd	5<	0.1>
12	Se	5<	-----

Also, the result of elements and metal analysis in the chemical and biological sludge of Mobin petrochemical complex is presented in the below tables (table 7, 8)

Table 7: metal analysis for chemical sludge from Mobin petrochemical complex by atomic absorption

row	Element	Unit	Results
1	Fe	ppm	32870
2	Zn	ppm	10880
3	Mn	ppm	1115
4	Cr	ppm	173
5	Cu	ppm	145
6	Ld	ppm	79 . 5
7	Ni	ppm	22 . 65
8	Co	ppm	0.1>
9	Ag	ppm	0.1>
10	Cd	ppm	0.1>

Table 7 : data from analysis of biological sludge from Mobin petrochemical complex

Row	Element	Unit	Results
1	Acidity	$-\mu s/cm$	6. 6
2	EC	ppm	2911
3	Organic materials	ppm	301400
4	Total neutralized materials	ppm	9200
5	Organic carbon	ppm	177000
6	N	ppm	39500
7	Fe	ppm	31400
8	K	ppm	31080
9	Si	ppm	17700
10	Al	ppm	3906 . 25
11	K	ppm	1780
12	NO3	ppm	116 . 66
13	Mn	ppm	101
14	Cu	ppm	24 . 95
15	Cr	ppm	15 . 25
16	Mo	ppm	11 . 19

Using sludge and ash in cement

Table 8: different chemical compounds in raw cement and produced ash from burning the sludge (unit %)

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3
Cement	20.5	6.5	3.2	1.9	62.5	0.4	0.78	-	2.2
Ash	28.1	16.6	10.4	1.4	5.61	0.82	2.34	12.1	0.24

As it can be seen, the amount of iron and silicon within sludge ash is very high, and aluminum has the third high amount after that, whereas its calcium and sulfur content of it is very low in comparison with raw cement.

Table 9 : type and concentration of heavy metals in sludge and the ash

Materials	Heavy metals	Pb	Cd	Cu	Cr	
Raw sludge	Total weight(mg/k)	0.28	1.6	9.51	33.32	176.57
Ash	Total weight (mg/kg)	1.2	4.81	21.96	89.64	567.3
	TCL (mg/L)	0.017	ND	0.1	3.81	-
	TCLP rules (mg/L)	5	1	5	15	-

As it can be seen in table 10, the amount of copper and zinc in these two is so much high that their amount in resulted ash is higher than raw sludge.

Burning the sludge at 1093 °C will improve resistance properties of the cement, so we indicate the properties of this cement at 1093 °C and mixture of cement with extra sludge ash with a different ratio (40:60, 30:70 and 20:80).

Table 10: properties of obtained cement in 1093 oC

C:SSA	A/S(%)	W/S	Bulk density		Water absorption (%)			
			Before fired	After fired	Before fired	After fired	Before fired	After fired
40:60	0.5	0.5	0.91	1.02	56.82	44.26	10.73	13.98
		0.6	0.77	0.88	71.79	54.27	9.58	12.71
		0.7	0.65	0.84	87.53	57.59	9.17	12.46
	0.9	0.5	0.86	0.96	60.73	48.89	10.57	12.41
		0.6	0.74	0.87	73.47	58.07	9.58	12.13
		0.7	0.62	0.71	92.89	70.41	9.04	11.30
	1.3	0.5	0.82	0.93	64.15	50.36	9.95	12.28
		0.6	0.67	0.81	86.60	68.85	9.51	11.27
		0.7	0.62	0.70	89.90	70.75	8.98	10.88
30:70	0.5	0.5	0.93	1.11	57.01	37.74	9.87	17.55
		0.6	0.77	0.96	74.21	53.28	8.86	13.78
		0.7	0.67	0.89	89.61	67.71	8.73	12.96
	0.9	0.5	0.88	1.10	63.35	39.78	9.17	16.65
		0.6	0.73	0.91	76.98	55.81	8.86	13.48
		0.7	0.61	0.75	101.2	78.63	8.60	12.25
	1.3	0.5	0.86	1.06	63.46	45.44	8.94	15.05
		0.6	0.74	0.89	78.10	58.13	8.85	13.28
		0.7	0.62	0.70	96.03	74.23	8.53	12.19
20:80	0.5	0.6	0.76	1.06	74.68	42.19	8.77	19.34
		0.7	0.66	0.90	89.77	53.59	8.72	15.37
		0.8	0.58	0.73	106.72	70.76	8.67	12.21
	0.9	0.6	0.73	0.99	78.15	45.25	8.76	18.38
		0.7	0.61	0.84	100.1	60.86	8.71	15.35
		0.8	0.53	0.69	116.9	79.96	8.65	11.90
	1.3	0.6	0.72	0.93	79.93	49.96	8.72	14.57
		0.7	0.60	0.72	97.24	62.91	8.71	12.37
		0.8	0.52	0.63	113.5	82.86	8.58	11.14

A=ash, W=water, S=solids, C=cement, SSA=sewage sludge ash.

The results showed that conducting the experiment in low and high temperatures, the effects of water content on cement grow, and also the density of the resulted cement is better evidenced in comparison with another parameter. These results are shown in figure 4.

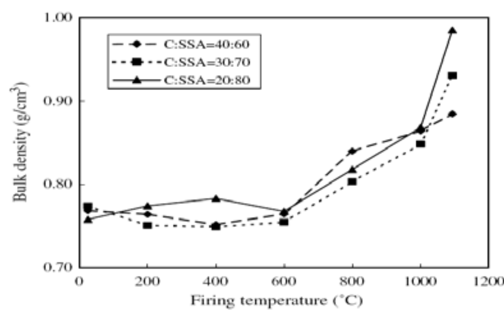

Figure 4: effects of burning temperature on cement density for different ratio of cement mixture with extra sludge ash.

As it can be seen in figure 4, with temperature increase and increment of ashes of the extra sludge ratio, the density of the cement will be increased. By using table 11 for cement properties after burning at 1093 °C and figure 5, and can be concluded that the water absorption by produced cement is approximately %80.

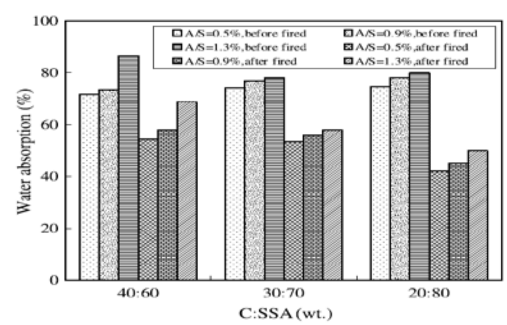

Figure 5 : water absorption rate for the cement

4. RESULTS AND DISCUSSION

1. Water content for these two types of sludge is almost equal, and based on the dehydration steps from the sludge, is relatively high. Also, there is

some water in ash samples which is probably due to mixing ash with the soil of the region.

2. A huge part of biological and chemical sludge is composed of organic materials, which decrease deeply in ash (from %55 to %7.5) which is because of burning organic materials which turned to gas.
3. The rate of iron oxides in these three samples were higher than other metal oxides, which can be a result of coagulators in wastewater treatment or the type of catalyst which used in a petrochemical complex.
4. The toxicity level of these samples is low due to the low content of heavy metals like chrome, cobalt and nickel and …, so it has a high potential for recycling and reuse in different industries.
5. The quantitative analysis on sludge samples is not coordinated with ash sample, which is due to non-permanent sludge burning in the different time period in the burner.

The ash resulted from chemical and biological sludge have properties like high silicon content which makes it a good choice for use in the cement and concrete, so with a little of changes, it can reach there.

The performed analysis on sludge and ash showed that the LOI rate in the sludge (which is a positive factor) is high and due to high amount of silicon and aluminum oxides in sludge and ash, it is capable of being used for heavy metals inhibition and fixation presented in ash and sludge through using them in asphalt.

According to performed investigations, the biological sludge and the resulted ash can be used as a chemical fertilizer in agricultural soils and pastures, and with slight optimization can be used to produce composts rich of organic materials and required elements.

The ashes resulted from burning chemical and biological sludge from Mobin petrochemical complex, have capacities like having elements like iron, copper, and chrome to be used in bricks, and with slight changes, this ash can be used to improve chemical and resistance properties of the bricks.

Altogether, with slight enrichment and increasing amount of some metals of the ash or output sludge of Mobin petrochemical complex can be industrially used for an application like fertilizer and brick industries.

Suggestions

1. Investigating the quality of input wastewater to Mobin petrochemical complex from another petrochemical complex of the region which requires identification and analysis of the compounds of this wastewater especially for heavy metals which is related to applied catalysts, in any of those petroleum complexes.
2. Preparation of an environmental instruction in order to separate each of biological and chemical sludge before their storage and heterogeneous mixing. So, it is advised to examine different burning mode for each chemical and biological sludge separately or in combination, for the different time period. It can result in a higher burning efficiency and how to reuse them for a better conclusion.
3. Reassessment of burner site of the complex in order to identify the reason of high organic percentage in the ash.

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