Journal of Fundamental and Applied Research **Vol. 3**, Issue 3 (2023) **20230013**

Received: 12 July 2023 / Accepted: 7 September 2023
Published online: 8 September 2023
© 2023 The Author(s)

DETERMINATION OF THE CONTENT AND ANALYSIS OF TECHNICAL WATER OF OIL SLUDGE

Abdugoffor M. Khurmamatov,[1,*] Alisher U. Auesbaev,[1,†] and Zamir M. Khametov[2,‡]

[1] *Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, 100170 Tashkent, Uzbekistan*
[2] *Fergana Polytechnic Institute, Fergana street 86, Fergana city 150100, Uzbekistan*

Abstract. Oil sludge contains a large amount of heavy metals that enter the soil and are enriched with agricultural crops. Light components such as benzene, phenols, low molecular weight hydrocarbons, etc. contained in oil sludge can evaporate into the air, which pollutes the atmosphere and irritates the respiratory tract and skin. Disposal of oil sludge is a difficult task, since oil sludge has both resources and harmfulness. This will require, first of all, studying the physico-chemical compositions of oil sludge. In this article, a number of experiments were carried out, such as the study of the physico-chemical composition of the oil sludge of the Bukhara oil Refinery. Extraction of technical water present in the oil sludge and the study of its physico-chemical parameters. The experiments were carried out in laboratory conditions together with the laboratory of the Institute of Mineralogy of Resources, the composition of industrial water was studied on an Atomic Absorption spectrometer device. The hardness of water was studied by titration, the pH-medium of water was determined. The comparison of industrial water with clean water is also considered.

Keywords: oil sludge, water, titrator, salt composition, physico-chemical, characteristics

I. INTRODUCTION

In the process of oil extraction, storage, transportation and refining, oil is mixed with some impurities to form oil sludge (OS), which is a typical pollutant in the petrochemical industry [1, 2]. According to statistics, the global annual production of OS exceeds 10 million tons, of which China accounts for 6 million tons[3]. At the same time, due to the lack of effective cleaning agents, over 140 million tons of OS are being deposited in China [4]. In many countries, OS are classified as hazardous solid waste due to their complex composition, toxic and harmful substances, such as petroleum hydrocarbons, chemicals and heavy metals[5, 6].Improper disposal of OS can lead to serious environmental pollution and threaten human health [7]. Due to the huge volume of production and the harmfulness of OS, efficient and clean disposal methods have become an urgent topic in the field of energy and the environment[8, 9]. In addition, OS contains a large amount of organic hydrocarbons, which has a high potential for resource use. According to various sources, OS is roughly divided into oilfield oil sludge, bottom oil sludge of reservoirs and oil sludge of oil refineries[10–12]. OS also contains a large amount of heavy metals that enter the soil and are enriched by agricultural crops [12, 13]. Light components such as benzene, phenols, low molecular weight hydrocarbons, etc. contained in OS can evaporate into the air, which pollutes the atmosphere and irritates the respiratory tract and skin [14, 15]. Disposal of OS is a difficult task, since OS has both resources and harmfulness. After decades of development, common methods of disposal of OS are mainly divided into physical and chemical methods. Pyrolysis and gasification have excellent purification rates compared to traditional methods of treatment of OS (mechanical separation, solvent extraction, biodegradation, incineration, etc.) [16–18]. Many scientists around the world are working on the disposal of oil sludge. This will require, first of all, studying the physico-chemical compositions of oil sludge. As is known, the content of process water in oil sludge usually ranges from 10 percent to 30 percent or more [19, 20]. Industrial water exhibits a composite composition, comprising specific salts and minerals in quantifiable amounts, drawn from diverse sources. This composition encompasses elements such as iron, nitrates, nitrites, sulfides, chlorides, fluorides, ammonia, carbon dioxide, hydrogen sulfide, and dissolved oxygen. Within industrial facilities, technical water undergoes comprehensive scrutiny to ascertain its compliance with predefined standards and undergoes

* gafuri˙1980@mail.ru
† Corresponding Author: alisherauesbaev@gmail.com
‡ alisherauesbaev@gmail.com

purification processes to eliminate extraneous contaminants. The extent of purification is contingent upon the intended application of this fluid, with many industrial enterprises opting for less rigorous purification when not deemed essential. Process water is characterized by various quality parameters encompassing temperature, odor, particulate content, color, oxidizability, dry residue, hardness, and pH. In this article, the objective of this study is to analyze the physico-chemical characteristics of process water, separated from oil sludge, employing an Atomic Absorption Spectrometer (AAS).

II. METHODS AND MATERIALS

Determination of the technical water content of oil sludge. The research focused on analyzing oil sludge obtained from the Bukhara refinery, and it's worth noting that specific standards and GOST standards (State standards) for quantifying process water content in oil sludge may exhibit variation depending on the country and regional regulations. In Russia, GOST standards commonly employed for ascertaining water content in oil sludge include GOST 2477-64, GOST 2477-86, and GOST 10235-76. To quantify the water content in oil sludge, established methods, such as the Karl Fischer method, GOST standards, or distillation, are frequently utilized. Here, we provide a concise overview of the general procedure for determining water content in oil sludge through the Karl Fischer method, which is widely prevalent: Sample preparation: The oil sludge was well mixed and presented as a sample, usually in liquid form. Preparation of the Karl Fischer reagent: The Karl Fischer reagent was prepared, which is usually a solution of iodine, sulfuric acid and methanol. Titrator analysis: A Karl Fischer titrator was used to titrate the sample. This process involves adding the reagent to the sample with reverse titration until all the water in the sample reacts with the reagent. The titrator automatically measures the amount of reagent added. Calculation of water content: The volume of the added reagent was measured and used to calculate the percentage of process water content. To determine the water content , the following formula was used:

$$X = \frac{V \cdot n \cdot M \cdot 100}{m} \tag{1}$$

where: V - Karl Fischer reagent - the volume of reagent required to neutralize the water in the sample (ml); n- the normality of the reagent is the concentration of the reagent in normoles (eq/l); M- molar mass of water; m- oil sludge mass (g).

Analysis of oil sludge process water. In the laboratory, a series of analyses were conducted to assess the quality parameters of industrial water separated from oil sludge. Various methodologies, including titration, gravimetric analysis, and Atomic Absorption Spectrometry (AAC) with a ZEEnit-700P instrument, were employed for the determination of chemical composition. Initial quality indicators of the process water were ascertained through experimental procedures. To characterize the chemical and physical composition, titration techniques and other experiments were applied. The determination of water hardness involved a titration method using trilon B, while the presence of chlorine was determined through a titration method utilizing $AgNO_3$. Calcium and magnesium content was assessed using a titration method with trilon B, and carbonate concentration was determined via titration with HCl (0.01N). Sulfur content in industrial water was determined through a combination of titration and combustion methods within a muffle furnace. Subsequent investigations to determine heavy metal content in the water involved atomic emission spectroscopy with inductively coupled plasma. To assess the acid-base characteristics of industrial water, pH measurements were conducted using an I-150 MI pH meter. The analyses of industrial water were conducted in collaboration with the laboratory of the Institute of Mineralogy of Resources. For the determination of water hardness in industrial water samples separated from oil sludge, a titration-based procedure was followed. The sequence of the experiment entailed taking 10 mL of the process water under examination, adding 2 drops of methyl orange to yield a pinkish hue, followed by the addition of 3 drops of ammonia, and mixing to reach a 25 percent solution. This solution was placed on a titration apparatus equipped with a magnetic stirrer. Trilon B was then titrated into the solution until the color of the water changed to a bluish hue, allowing for the quantification of water hardness based on the consumption of Trilon B. In laboratory conditions, the assessment of dry residue in technical water was conducted. For this purpose, a Muffle drying cabinet was employed. The procedure involved taking a water sample, placing it in the Muffle cabinet at a temperature of 300°C, and periodically weighing it. The weighing process continued until a constant weight was achieved.

A. Results and discussions

In the process of assessing the water content in oil sludge according to GOST 2477-64, it was determined that the mass fraction of water in the oil sludge is 39 percent. Subsequently, an investigation into the characteristics of the separated industrial water was conducted, and the outcomes for certain properties of the process water are presented in Table 1.

Table 1 provides an overview of the findings regarding the properties of the process water. It is observed that the water exhibits a hardness of 3.40 mg-eq/l, indicating a moderate level of hardness. The pH value is measured at 6.30 at a temperature of 20°C, signifying a slightly acidic nature. The mineralization is considered average, with a dry residue of 300 mg/l. Furthermore, the process water is characterized by a hardness of 3.4 eq/l, suggesting a moderate hardness due to the presence of Ca^{2+} (both

 Copyright © 2023

Properties of Process Water	Indicators
Rigidity	3.4
pH	6.30
Non-carbonate	1.20
Carbonate	2.20
Dry residue (experimental)	300 mg/l
Dry residue (calculated)	263 mg/l
Transparency	Transparent
Colour	Slightly yellowish
Smell	Specific unpleasant
Sediment	Without sediment
Changes when standing	The smell partially disappears.

TABLE I. Results of Process Water Properties

Cations	Content (mg/l)	Content (Mg-eq/l)	Content (%-eq/l)
Na^+	17	0.73	15
K^+	1	0.05	1
NH_4^+	9	0.50	11
Ca^{2+}	56	2.80	60
Mg^{2+}	7	0.60	13
Fe^{3+}	<0.3		
Fe^{2+}	<0.3		
Total	90	4.68	100

TABLE II. Analysis of Process Water Cations

non-carbonate and carbonate forms). The technical water exhibits transparency, a faint yellowish coloration, and a distinctive odor, which partially diminishes upon standing. There are no visible sediments in the water. Subsequent analyses, conducted in collaboration with the laboratory of the Institute of Mineralogy of Resources, employed an Atomic Absorption Spectrometer device to quantitatively determine the levels of Na^+ and K^+, as detailed in Table 2. Additionally, measurements of Fe^{3+} concentrations were performed using both Spectrophotometer and titration methods, with the results presented in Tables 2 and 3.

The analysis from Tables 2 and 3 reveals that the presence of calcium and sodium in the process water contributes to its moderate hardness, and the presence of salts exerts a noticeable influence on water quality. The presence of anions has an impact on the pH of the water, resulting in a slightly acidic environment. Additionally, the presence of cations in the process water is responsible for the observed average hardness. Based on the analytical results, we can deduce the salt composition of the process water that has been separated from the oil sludge originating from the Bukhara refinery. In scientific terms, we can infer the salt composition of the industrial water, which has been extracted from the oil sludge at the Bukhara refinery, by evaluating the observed data and can write a formula for the salt composition of industrial water:

$$\frac{0.3 \cdot (\mathrm{HCO_3^{47}} \cdot \mathrm{Cl^{27}} \cdot \mathrm{SO_4^{20}})}{\mathrm{Ca^{60}} \cdot (\mathrm{Na} + \mathrm{K})^{16} \cdot \mathrm{Mg^{13}} \cdot \mathrm{NH_4^{11}}} \tag{2}$$

Anions	Content (mg/l)	Content (Mg-eq/l)	Content (%-eq/l)
Cl^-	46	1.30	27
SO_4^{2-}	44	0.92	20
NO_2^-	0.01		
NO_3^-	16	0.26	6
CO_3^{2-}	-		
HCO_3^-	134	2.20	47
Total	240	4.68	100

TABLE III. Analysis of Industrial Water Anions

Copyright © 2023

III. CONCLUSIONS

In summary, it is evident that 39 percent of the composition of oil sludge is comprised of water. There exist various techniques for isolating this water from the oil sludge, and once separated, it can be subjected to chemical purification processes, rendering it suitable for applications in fisheries. The physicochemical composition of the industrial water has been thoroughly examined, culminating in the derivation of the salt composition formula. The data presented in the tables highlights the necessity for the further treatment of process water obtained from oil sludge before it can be employed effectively. The current quality indicators of industrial water separated from oil sludge do not align with its direct use without undergoing purification and softening processes. This is essential due to the presence of petroleum byproducts, salts, and a moderate level of water hardness, all of which could pose environmental and economic challenges if the water were utilized in its untreated state.

REFERENCES

[1] Z. Gan et al. Experimental investigation on smoldering combustion for oil sludge treatment: Influence of key parameters and product analysis, Fuel 316 (2022), 123354, https://doi.org/10.1016/j.fuel.2022.123354.

[2] S. Zhao et al. Study on the oil-sludge separation by thermochemical method in rotating packed bed, Chem. Eng. Process. 174 (2022), 108878, https://doi.org/10.1016/j.cep.2022.108878.

[3] C. Lee et al. Valorization of petroleum refinery oil sludges via anaerobic co-digestion with food waste and swine manure, J. Environ. Manag. 307 (2022), 114562, https://doi.org/10.1016/j.jenvman.2022.114562.

[4] W. Ran et al. Rheological properties of asphalt mortar with silane coupling agent modified oil sludge pyrolysis residue, Constr. Build. Mater. 329 (2022), 127057, https://doi.org/10.1016/j.conbuildmat.2022.127057.

[5] X. Zhang et al. A makeup remover-inspired chitosan-based emulsion for heavy oil removal in oily sludge treatment, Fuel 330 (2022), 125588, https://doi.org/10.1016/j.fuel.2022.125588.

[6] Y. Castillo Santiago et al. Reaction-front and char characterization from a palm kernel shell – oil sludge mixture under oxygen lean regimes in a fixed-bed gasifier, Fuel 333 (2023), 126402, https://doi.org/ 10.1016/j.fuel.2022.126402.

[7] Z. Xu et al. The influence of key reactions during hydrothermal carbonization of sewage sludge on aqueous phase properties: A review, J. Anal. Appl. Pyrolysis 167 (2022), 105678, https:// doi.org/10.1016/j.jaap.2022.105678.

[8] A. Muratova et al. Physiological and biochemical characteristic of Miscanthus × giganteus grown in heavy metal – oil sludge co-contaminated soil, J. Environ. Sci. 115 (2022) 114 – 125, https://doi.org/10.1016/j.jes.2021.07.013.

[9] A. Kamali et al. Optimized catalytic pyrolysis of refinery waste sludge to yield clean high quality oil products, Fuel 328 (2022), 125292, https://doi.org/10.1016/j.fuel.2022.125292.

[10] C. Ke et al. Biotreatment of oil sludge containing hydrocarbons by Proteus mirabilis SB, Environ. Technol. Innov. 23 (2021), 101654, https://doi.org/10.1016/j.eti.2021.101654.

[11] C. Zhao et al. Method of smoldering combustion for refinery oil sludge treatment, J. Hazard. Mater. 409 (2021), 124995, https://doi.org/10.1016/j.jhazmat.2020.124995.

[12] R. Muneeswari et al. Biocatalytic lipoprotein bioamphiphile induced treatment of recalcitrant hydrocarbons in petroleum refinery oil sludge through transposon technology, J. Hazard. Mater. 431 (2022), 128520, https://doi.org/10.1016/j. jhazmat.2022.128520.

[13] M. Roudneshin, A. Azadeh, A novel multi-objective fuzzy model for optimization of oil sludge management by considering Health, Safety and Environment (HSE) and resiliency indicators in a gas refinery, J. Clean. Prod. 206 (2019) 559 – 571, https://doi.org/10.1016/j.jclepro.2018.09.142.

[14] Z. Sun et al. Innovative process for total petroleum hydrocarbons reduction on oil refinery sludge through microbubble ozonation, J. Clean. Prod. 256 (2020), 120337, https://doi.org/10.1016/j.jclepro.2020.120337.

[15] Z. Xu et al. Hydrothermal carbonization of sewage sludge: Effect of aqueous phase recycling, Chem. Eng. J. 387 (2020), 123410, https://doi.org/10.1016/j.cej.2019.123410.

[16] D. Xia et al. Effect of steam jet on oil reclamation and purification from layered oily sludge, Fuel 263 (2020), 116731, https://doi.org/10.1016/j.fuel.2019.116731.

[17] H. Zhong et al. A preliminary study of the preparation of shale stabilizer with oil sludge - from waste to resource, J. Pet. Sci. Eng. 161 (2018) 50 – 60, https://doi.org/10.1016/j.petrol.2017.11.065.

[18] K. Hui et al. Status and prospect of oil recovery from oily sludge:A review, Arab. J. Chem. 13 (8) (2020) 6523 – 6543, https://doi.org/ 10.1016/j.arabjc.2020.06.009.

[19] Z. Ding et al. Hydrogen peroxide combined with surfactant leaching and microbial community recovery from oil sludge, Chemosphere 286 (2022), 131750, https://doi.org/10.1016/j. chemosphere.2021.131750.

[20] D. Ramirez et al. Characterisation of oil sludges from different sources before treatment: High-field nuclear magnetic resonance (NMR) in the determination of oil and water content, J. Pet. Sci. Eng. 174 (2019) 729 – 737, https://doi.org/10.1016/j.petrol.2018.11.078.

 Copyright © 2023