The Oily Soil Reclaiming by the Spent Selective Sorbent

D O Ignatkina¹, A A Voytyuk², I M Shevtsova³
¹Department of water supply and water disposal, Volgograd state Technical University, Institute of Architecture and Construction, Academicheskaya Street, house 1, Volgograd, Russia
²Department of water supply and water disposal, Volgograd state Technical University, Institute of Architecture and Construction, Academicheskaya Street, house 1, Volgograd, Russia
³Department of water supply and water disposal, Volgograd state Technical University, Institute of Architecture and Construction, Academicheskaya Street, house 1, Volgograd, Russia

E-mail: viv_vgasu@mail.ru

Abstract. The article is about one of the possible method of the spent sorbent utilization as a recultivated addition for oily soil liquidation. The main sources of the oil pollution are mentioned. It is suggested to use the spent selective sorbent as addition for oil liquidation, which is consisted of 70% of the spent active ooze and 30% of mineral component. The physicochemical properties of the spent sorbent based on the excess active ooze are studied. The average data of nitrogen, phosphorus, potassium containing is mentioned. It is experimentally proved that oily soil, which contains a great amount of organic matter, decreases the toxicity of heavy metals, and plants can delete them. Brassica juncea, which belongs to mustard family, was chosen for the laboratory research as an effective accumulator of the heavy metals ions. The heavy metal ions are absorbed during the process of the Brassica juncea seed sprouting and then they are moved to the top of the plant that is why at the end of the basic process of vegetation the toxic polluted biomass is reduced and utilized. There are recommendations for the preliminary preparation of the spent sorbent before using it as the recultivated addition in the oily soil.

1. Introduction
Ecologically safe technology of removing ions of nickel, zinc, copper before biological purification by sorbent method using spent active ooze identifies the necessity of the solution of a problem of further spent sorbent utilization. New waste, received during the wastewater purification from the heavy metal ions (IHM), can be regenerated with the acid and further clean water washing. The disadvantage of this process is its economic and ecological inexpedience. That is why the authors suggest utilizing spent selective sorbent for the oily soil reclaiming (OS). This ecological problem is studied in the article.

The main sources of oil pollution are oil-producing factories, systems of fuel transfer, oil terminals and oil tank farms, oil products storages, railway transport, river and sea crude oil tankers, petrol stations. The number of oil wastes is about hundred thousand cubic meters. The great amount of oil
sludge storages, built in 1950s, have become not a way of oil waste prevention but in the source of such pollutions [1].

Oil waste differs from many other human impacts because it can be a result of so-called shock load, causing fast reaction of the environment [2,3].

Natural soil purification from the oil is a long process. That is why creating reclaiming methods from OS is one of the main problems for decreasing human impacts on the environment.

The process of ecosystem self-healing, which is caused by oil, is rather difficult. The factors, which limit the process of carbon decomposition, are air-gas soil condition, temperature and biogenic elements such as nitrogen, phosphorus, potassium [4,5]. Oil pollution of soil makes gaseous exchange worse. The OS treatment, which makes aeration better, stimulates the microorganism activity intensifying acid processes. Moreover, a large biologically active layer with improved agrophysical properties is made along with it [6,7]. The speed of the oil decomposition depends on acid of the soil. More favourable pH value for the microorganism growth and development in the oil pollution conditions must be close to neutral. That is why acid soil is exposed by chalking[8,9].

It is a fact [10,11] that sowing on OS such plants as alfalfa, bean cultures and grasses with an extensive root system makes air-gas condition better and also enriches it with nitrogen and biologically active elements.

Nowadays about 200 different sorbents for oil spill liquidation are used all around the world. They are divided on inorganic, natural, mineral and synthetic ones [12,13]. The quality of the sorbents are defined according to their oil capacity, hydrophobic level, buoyancy after oil sorb, opportunity of the oil desorption, sorbent regeneration and utilization [14,15,16]. Using sorbents can be combined with the mechanical methods of the oil gathering. It must be mentioned that the mechanical methods can be used either before or after using the oil fixing sorbents to prevent emulsion forming [17].

The authors suggest using spent sorbent as a reclaiming addition to oil liquidation. It consists of almost 70% of the spent ooze (table 1) [18], which contains a lot of necessity nutrients for plants. However, spent sorbent is full of different toxicity elements, for example Zn$^{+2}$, Cu$^{+2}$ и Ni$^{+2}$. That is why a technology of OS reclaiming must include using spent sorbent together with the special types of the plants.

| Component composition, % mass. | density, g/dm$^3$ | Composi- on of the basic fraction, mm | Mechanical reliability, % |
|-------------------------------|------------------|----------------------------------|-----------------------------|
| Active ooze                   | SiO$_2$ Fe$_2$O$_3$ CaO AI$_2$O$_3$ N$_2$O | 112 3.5 63.8 | 69.5 23.7 1.2 2.1 0.8 2.7 |

Using spent selective sorbent as an organic addition to the OS reclaiming is a better way of its utilization because it is a combined fertilizer with high consistence of nitrogen, phosphorus and different microelements.

The average data of nitrogen, phosphorus and potassium consistence is in the table 2.
As it is obvious from the table 2, active ooze is a value organic fertilizer with large amount of nitrates and phosphates but their consistence in it changes in a wide range. It is explained by the differences of the wastewater components.

In spite of the fact that there is a high level of IHM in the spent sorbent, it can be used in OS reclaiming. As it was mentioned in the researches by V.I. Kudryashova, heavy metals have highly stable compound with humic acids and fulvoacid in the soil. The soils with a big amount of organic matters decrease heavy metals toxicity and using plants remove them.

The ways of plant resistance to the IHM overage can be shown in different directions. One can accumulate high ITM concentration, others long to decrease their supply [20].

The most plants keep the maximum amount of IHM in roots, then it comes stems and leaves and after that IHM are in the parts with reproductive function [21,22]. Such hyperaccumulative genotypes of the plants are a basis for rhizoremediation (from the Greek “phyton” means “plant” and the Latin “remedium” means “regenerate”). It is a modern technology of soil cleaning with the help of wild-growing plants. The rhizoremediation is proved as an effective and economically profitable method of the soil purification from some organic and inorganic pollutants [21,22,26].

Most of the wild-growing plants, which can accumulate and destroy IHM, are mustard family, which are close relative to a cabbage and mustard. Brassica juncea as a type of mustard is a highly effective accumulator of zinc, copper and nickel [23,24]. Also, this plant satisfy some other demands: has a large biomass, has a massive root system, has a tolerant attitude to the high concentration of IHM, can absorb and accumulate some heavy metals connections. However, it must be mentioned that in the process of juncea seeds sprouting IHM are absorbed with roots. Then, they comes to the ground part of the plant, that is why after the process of the period of vegetation the polluted biomass must be utilized and reduced [25].

The measuring of the root length takes place after 24, 48 and 72 hours after sprouting with the help of a ruler in millimeters. After 72 hours after sprouting and analysis all the results of seeds the roots are cut and weighted on the counter balance in grams. During the length measuring of all the studying samples the average arithmetic mean was taken as a result (table 3).

### Table 2. The content of the main nutrient matter in the spent selective sorbent.

| Point No. | Nutrient matter     | Spent selective sorbent, % | sewage sludge, % | Active ooze, % |
|-----------|---------------------|----------------------------|------------------|---------------|
| 1         | Total Nitrogen      | 2,0-8,0                    | 1,6-6,0          | 2,4-10,0      |
| 2         | Total phosphorus (P₂O₅) | 1,0-7,0                    | 0,6-5,2          | 2,3-8,0       |
| 3         | Total potassium (K₂O) | 0,2-0,5                    | 0,1-0,6          | 0,3-0,4       |

Note: The percent concentration is on the mass of the dry matter.

### Table 3. Influence of conditions on juncea seeds sprouting.

| Parameter of the researching | Control | Sulphate (Zn, Ni) | Kerosine | Sulphate (Zn, Ni) + Kerosine |
|------------------------------|---------|------------------|----------|-----------------------------|
| Energy of sprouting, %       | 80±2    | 78±2             | 76±2     | 76±2                        |
| Relative energy of sprouting, in % | 100   | 98               | 94       | 94                          |
| Length of roots, mm          | 10,0±0,2| 8,0±0,2          | 8,0±0,2  | 5,6±0,2                     |
| Relative length of roots, %  | 100     | 90               | 80       | 79                          |
| Mass of roots, gr            | 0,37±0,2| 0,29±0,1         | 0,24±0,1 | 0,22±0,1                    |
| Relative mass of roots, %    | 100     | 85               | 65       | 63                          |

From the table 3 it is obvious that the treatment of the juncea seeds slightly influences on the sprouting.

The laboratory researches of defining the seeds sprouting energy were done on the Brassica juncea. According to the Union State standard 12038-84 the definition of the germination was done. The seeds
were treated with the heavy metal salts solution (zinc sulphate and nickel) with concentration from 0.001 mg/l to 0.1 mg/l either with or without kerosene (figure 1).

1- A control sample of the soil without the spent sorbent; 2- a sample of the soil with the spent sorbent; 3- a sample with oil and spent sorbent.

Figure 1. The dependence of the Brassica juncea length from the concentration of the spent sorbent in the soil.

The definition of the phytotoxicity of the seeds sprouting and the beginning growth of the Brassica juncea sprout was done according to the Union State standard ISO 22030-2009. The experiment proved that suggesting addition does not have strongly pronounced toxicity. Toxicity has an example with oil.

So, the results of the researches showed a potential opportunity of using the spent sorbent as a material for OS reclaiming. This method of removing organic and inorganic pollutants by the entering of the spent active ooze and a mineral compound together with the plants is an alternative method of the OS reduction to the expensive one.

Organo-mineral composition for OS reclaiming must look like a loose mass with humidity not more than 50-60%.

It is advantageous to organize a perennial control for IHM containing in the soil and the plants at the factories, where the spent sorbent will be used as a reclaiming addition. It allows making a database about heavy metals actions and will have a certain meaning in setting a doze and frequency of getting the reclaiming addition.

The doze and frequency of getting the reclaiming addition depend on the following conditions:
- soil conditions: containing of humus and nutrient elements, reactions of the soil surroundings, a granulometric compound, an underground water level, etc;
- factors of organic material containing, nutrient elements and heavy metals in the reclaiming addition according to State Standard 17.4.3.07-2001.

The doze of the addition while OS reclaiming is calculated according to the necessity of making a fertile soil layer of the certain power and containing of the set amount of organic material. While readding on the same soil the doze is calculated according to the lack of the certain nutrient element.

Precaution in the addition doze measuring is necessary because there is no information about using it in the industrial conditions and a lack of knowledge about IHM actions with oil and plants in the long-term mode.

According to the long scientific and industrial experience, State Standard 17.4.3307-2001 and SanPin 2.1.7.573-96 about using treating facility sediment and in the view of the similar foreign studies, frequency and standards of the addition getting is set gradedly.
In the particular method of the OS reclaiming the set sorbent is prepared beforehand. Firstly, it must be dried and compressed up to the air-dry consistence in the natural conditions in the ooze tank during the summer. Then it must be got and set on the compost area, where, according to SanPin 2.1.7.573-96, it must be during 1-2 years up to the pathogenic microorganism disappearing. The prepared spent sorbent must be studied on the biogenous elements containing for plant feeding. For this reason, a microbiological analysis for microorganism containing must be done. In the end, the spent sorbent must be set on the OS in the amount of 25 t/ha in conversion on dry material. It is necessary to loosen the soil with decreasing of density up to 10-30% to mix it with the oil layer better. In spring the area is sown with the Brassica juncea. The constant control of oil distraction is done by analysing a test from the land lot.

2. Conclusion
To sum up, it is possible either to make low-waste technology of city wastewater purification or to reclaim the oil polluted soil using the spent sorbent with the active ooze.

3. References
[1] Minakiov V V, Krivenko S M, Nikitina T O 2002 New technologies of oil pullution purification Ecology and factories (Russia, May) pp 7-9
[2] Drugov U S, Rodin A A 2000 Ecological analyses is oil spill. (SPb.) pp 16-17
[3] Charekhan P R 1980 Problems of Environmental Pollution and its Hasards in Refinery and Petrochemical Plants Chem. Age India. Vol 31 4 pp 331-334
[4] Atlas R M 1981 Microbiol degradation of petroleum hydrocarbons and environmental perspective Microbiol. Rev. Vol 45 1 pp180-209
[5] 2001 Technologies of the soil treatment, polluted with oil Sprav (M.: REFIA Niah-Nature) pp 7-16
[6] Farrington J 1985 Oil pollution: a decade of research and monitoring Oceanus Vol 28 3 pp 2-13
[7] Koronelly T V 1996 Principles and methods of the biological destruction intensification of hydrocarbon in the enveroment Applied Biochemistry and Microbiology Iss 32 6 pp 579-585
[8] Zaydelman F R 2008 Methods of reclamative studying and soil research (M.: Kolos) 486 p
[9] Kulikov O V 2002 Industrial soil and water pollution with oil Drilling and oil 2 pp 26-28
[10] Robinson B H 1998 The potential of Thlaspi caerulescens for phyto remediation of contaminated soils Plant. Soil 1 pp 47-56
[11] Scott D 1996 Kanningen and David W VL Promises and prospects of rhizoremediation plants Physiol 110 pp 715-719
[12] Moskvicheva E V, Sidyakin P A, Schitov D V, Ignatkina D O 2014 Processing of factories wastes in the secondary raw materials as a circumstance of the factory safity Vestnik VGASU.: Building and Architecture (Volgograd: VGASU) 37(56) pp 201-211
[13] Moskvicheva E V, Saharova A A, Gonchar U N, Ignatkina D O, Kuzmina T A 2013 Wastewater purification using the mixed reagent from the oil waste Vestnik VGASU.: Building and Architecture (Volgograd: VGASU) 34(53) pp 114 - 119
[14] Orlov D S 2002 Ecology and protection of the biosphere in chemical pollution: Stud. handbook for chemical university (M.: Vysh. shk.) 334
[15] Kamenschikov F A, Bogomolskii E I 2003 Oil sorbents (Moscow) Izhevsk: Institution of the computer researches 268 p
[16] Pat. 2644880 The Russian Federation, MPK B01J 20/24 (2006.01) The way of getting the sorbent for the wastewater purification D O Ignatkina, A A Voytuck, A V Moskvicheva, E V Moskvicheva, A A Geraschenko, (VSTU) №2017108520 ord. 14.03.2017 publ. 14.02.2018 Bul 5
[17] Ioschenko U P, Kablov V F, Zaykov G E 2008 Oil biodegradation in polluted soil using polymeric complex mixture (chitosan – protein of milk whey) – active ooze Plastic mass 7
[18] Pat. 2542259 The Russian Federation, MPK B01J 20/10 The way of getting the sorbent [Text] Voytuk A A, Moskvicheva E V, Saharova A A № 2013146300/05 ord. 16.10.2013 publ. 03.12.2014 Bul 5

[19] Kudryashova V I 2003 Heavy metal accumulation with wild plants [Text]: Dis. … Cand.Biol.Sci: 03.00.16 (Saransk) 144 p

[20] Grünther T 1996 Effects of ryegrass on biodégradation of hydrocarbons in soil Chemosphere Vol 33 2 pp 203-215

[21] Dushenkov S M, Kapulnik Y, Blaylock M 1997 Phytoremediation: a novel approach to an old problem Global Enviromental Biotechnology Ed.Wise D L (Amsterdam: Elsevier Science B V) pp 563-572

[22] Ris G, Ellis B 1993 Integrated engeneering and scientific methods of polluted soil and water processing Chemistry with the interest of persistent development 2

[23] Bagantsova M V 2011 Using the Brassica juncea and rye grass for phytoremediation of the lead polluted soil [Text]: synopsis. dis. … Cand.Biol.Sci: 03.00.16 (Moscow) 23 p

[24] Voskresenskaya G S 1987 The Brassica juncea Manual of the selection and seed growing of oilseeds V S Pustovoyt (M.) pp 173-235

[25] Bashmakov D I 2002 Heavy metal accumulation with some of the Embryophytes in different habitats Agrochemistry 9 pp 66 – 71

[26] Karpenko A V, Karpenko D V, Solovev D B 2020 Influence of Crumb Rubber Vulcanization Degree on the Quality of Asphalt Concrete Used in Road Construction Materials Science Forum 992 31-35. [Online]. Available: https://doi.org/10.4028/www.scientific.net/MSF.992.31