Testing the Biodegradation of Contaminated Water with Petroleum Products Through Conventional Treatment in Comparison with Treatment Through Biological Sludge Enriched with Activated Charcoal

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In the study was followed the evolution of microorganisms population in biological sludge on a contaminated water with contaminators with known concentrations, maintaining its life at optimum climate. Tests were conducted to find answers on the ability of microorganisms to biodegrade different contaminators and to find different microbial strains able to degrade certain contaminators. The identification of specific strains for each contaminator separately help to restore biocenosis from a wastewater treatment plant that could be affected by pollution incidents and can help the effective biodegradation of wastewater. This experiment studies biodegradation of contaminators in presence of wastewater coming from the water treatment plant using biological sludge adapted to this kind of contaminators evolution of such systems to eliminate pollutants in two comparative treatments: the treatment with biological sludge and the second system by adding activated charcoal into the biological sludge.

Keywords: biological sludge, biodegradation, activated charcoal

A pollutant is any natural or unnatural material that is present in the environment at unnaturally high levels. Concern about pollution is meaningful only in the context of a pollutant impact on the biosphere. How a pollutant affects the biosphere has been conventionally characterized in terms of easily quantifiable measures such as the chemical oxygen demand (COD), biochemical oxygen demand (BOD), *p*H and total suspended solids. These measures are important, but they are grossly insufficient for assessing the full impact of a discharge on the biosphere. Many pollutants directly affect the metabolic biochemistry of the diverse life forms that inhabit the various ecosystems. When the biochemical impact is adverse, the pollutant is toxic.

One of the popular means for removal and recovery of organic water pollutants is by adsorption. Indeed, recently there has been an increasingly large amount of literature devoted to the study of adsorption for the removal of aqueous organic species such as phenols and substituted phenols using activated carbon and macrorecticular polymeric resins [1-3]. Although adsorption of phenolic compounds onto adsorbents such as *granular activated carbon* GAC and polymeric resins is relatively simple, the process of regenerating the adsorbent by desorption of the organic adsorbate still poses a major challenge to workers in this field, notably because of the high affinity of the compounds to the sorbent surface.

The idea of using GAC for the removal of organics is not new. In Europe, GAC has been used for years to remove organics associated with taste and odors, as well as for color removal [4-7]. However, only recently has it been suggested that microorganisms, known to proliferate on GAC filters,may be important in the removal of organic substances from influent waters. Various workers have suggested enhancing the biodegradability of humic materials through preliminary ozonation. This combined ozone-GAC treatment, used before chlorination, has been termed the biological activated carbon (BAC) process. Proponents of this process contend that it is capable of enhancing the adsorptive capacity of GAC and extending the lifetime of GAC columns almost indefinitely, provided microbiological colonization of GAC is maintained. Treatment efficiencies during such extended lifetimes ordinarily do not equal those of fresh carbon, but the proponents of the BAC process contend that raising empty bed contact times allows the BAC process to achieve desirable treatment efficiencies.

Toxic substances from wastewater in most cases act as inhibitors of cellular enzymes or through other means, for example all inhibitors that react with groups of proteins attack not only enzymes but also different structure proteins from the cell [8-10].

Biological processes of wastewater sewage are processes during which the biodegradable organic matter from wastewater and sludge are decomposed by microorganisms, mainly bacteria [11,12]. The processes through which microorganisms degrade substances in ultimate degradation products are:

- aerobic decomposition;
- anaerobic decomposition;
- anoxic decomposition (in the presence of nitrate ion).

Biological purification of waste water can be achieved by one or a succession of these stages of processing. Most often used is made in the presence of aerobic activated sludge or oxidation on layers with bacteria.Removal of organic substances dissolved in water is made through their adsorption to bacterial cell surface. Thus, from this process results new bacteria cells and metabolites: CO_2, mineral salts, etc. The resulted cellular material is in the form of floaters, or skins bonded relatively easy to settle [13-16].

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The current legislation provides a superior quality of wastewater discharged into the environment and should not contain toxic substances. Biofilters, aeration basins (aeration tanks) and storage tanks are used for the biochemical purification of waste water.

Active charcoal is a material which aims to help improve the quality of treated water which has superior adsorbent properties and is able to retain certain organic compounds due to large specific surface resulting from internal pore network [17-20].

Activated charcoal is to protect the microorganisms in activated sludge against heavy loads of organic compounds by adsorption of organic compounds, their release through desorption is slow and accompanied by their biodegradation. This stage is known in the literature as bio regeneration phase. Through an adsorption process the molecules are trapped within the cavities and eventually into the smaller channels, as they become increasingly narrow that they can advance. Smaller molecules can enter through the smallest pores while larger pores allow access to complex molecules. Examples of elements that can be removed by the charcoal through the process described above: iodine, phenol yellow water , amino acids, copper, chromium, iron, mercury, chlorine, chloramines, hydrogen sulfide, malachite green, sulfur and antibiotics.

Experimental part

Experiments were made in a micropilot treating system (fig. 1); the required air was set by a valve that adjusted optimal air flow received in the system (the required dissolved oxygen was measured every 3 h from the air tanks ranged between 3-5 mg / L). It starts supplying from the supply vessels, under the established supply method (set of 1mL / min). Then start circulating pumps which are adjusted to a recirculation flow of 1 mL / min. The installations functioned without interruption until it has exhausted all the water volume of the supply vessels. Equipment used for analysis are power microscope to view biological sludge, pH meter electronic and oxygen meter, and biological material are: activated sludge composed of bacteria, metazoaires and specialized protozoa for treating water.

The experimental plant used in the laboratory is composed of:

- supply-vessel with 5 L capacity and mounted at heights;
- air-spray system for maintaining the viability of activated sludge;
- air tank with 700 mLcapacity, 7 cm diameter and 50 cm length, equipped at the bottom with connecting pipe through which air is introduced into the system to provide the necessary oxygen for micro fauna present in the biological sludge and for maintaining the bacterial suspension in contact with the water supplied with contaminators;
- the nozzle is mounted above a frit with fine pores through which oxygen diffuses in the bio filter.

The experiment used two identical systems. In the first installation was followed the evolution of biological sludge and in the second installation the evolution of contaminators biodegradation with biological sludge and activated carbon. There have been used nutrients rich in nitrogen and phosphorus complex combinations of nitrogen – NPK and trisodium phosphate in a constant ratio of 5:1. This representing the optimal dosage for the viability of the activated sludge. Nutrient analysis of the nutrients were carried out based on current standardized methods following the evolution of concentrations for nitrates, nitrites, ammonium, total nitrogen and total phosphorus.

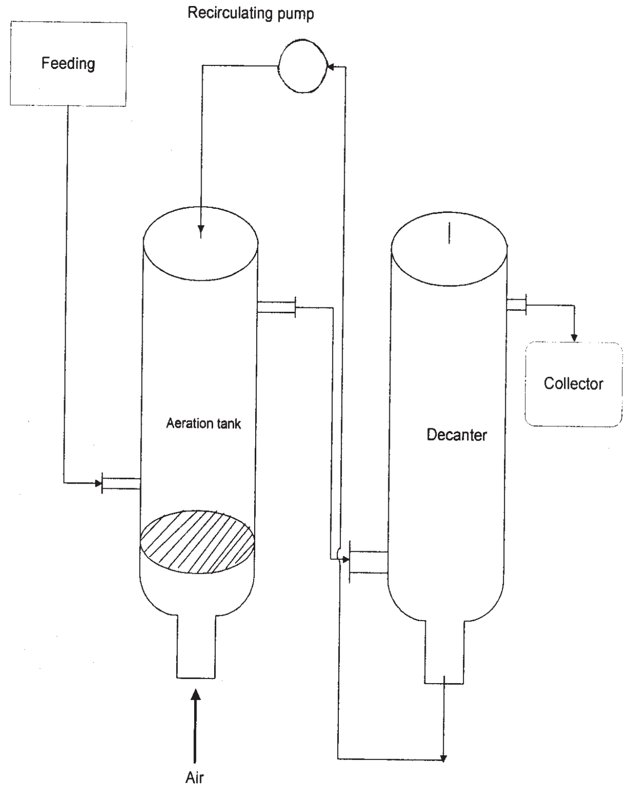

Fig.1 Schematic presentation of the laboratory installation

The source of food for the biological sludge is provided by the water contaminated with petroleum products collected from an oil refinery. For the petroleum product it was conducted the analysis of the total extractors petroleum. The functioning principle of bio filter system is as follows: the flow of waste water is realised uniformly with a rate of 1mL/min in the air tank where it meets the active biologically sludge where the treatment takes place.

From the air tank through the discharge pipe, the overflowing wastewater in combination with the activated sludge enters the second decanter, where a gravitational decantation process takes place and the decanted sludge is recycled in the air tank by the help of a recirculation pump.

In the first installation. the decanted and purified water is collected and analyzed. A volum of 30mL CMX is used with which are filled both air tanks from the two installations, the analyze is determined by reading the volume of sludge containing IMHOFF glass at every 30 minutes. In the second installation is added in the air tank, over the biological sludge, a quantity of 50 g / L activated charcoal more than in the first installation. Supply vessels were filled in both installations up the 5 L each with waste water coming from a water sample collected from the Parshall entry of a water treatment plant.

Results and discussions

The chemical quality of the wastewater used in the experiment had the characteristics presented in table 1.

After exhausting the entire amount of the waste water from the supply vessels of the two installations it was analyzed chemically the treated water collected from two treating systems (table 2). Chemical analyzes indicate an increase for the quality of the treated water by using active carbon with biological sludge. The biological sludge has a good evolution, its volume being increased approximately three times.

Nr. crt.	Parameter	Value
1.	pH	7.2
2.	Dissolved Oxygen mg/l	3.8
3.	CCO-Cr, mg/l	185
4.	Sulphonic acids , mg/l	35
5.	Extraction, mg/l	112
6.	Suspension, mg/l	85
7.	Residue, mg/l	650
8.	Phenol, mg/l	12

Table 1
INITIAL CHARACTERISTICS OF WASTEWATER

Nr. Crt.	Parameter	System I biological sludge	System II Biological sludge and activated carbon
1.	pH	7.4	7.2
2.	Extraction, mg/l	47	32
3.	CCO-Cr, mg/l	128	96
4.	Sulphonic acids, mg/l	12	8
5.	Suspension, mg/l	14	21
6.	Residue, mg/l	108	94
7.	Phenol, mg/l	2	1.4

Table 2
THE QUALITY OF THE WATER EVACUATED FROM THE TWO INSTALLATIONS

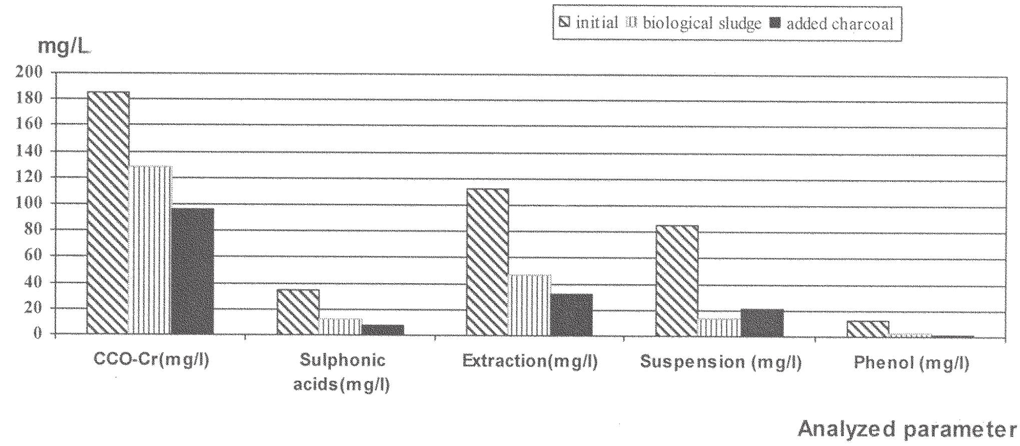

Fig. 2. The variation of contaminators biodegradation in the two parallel systems

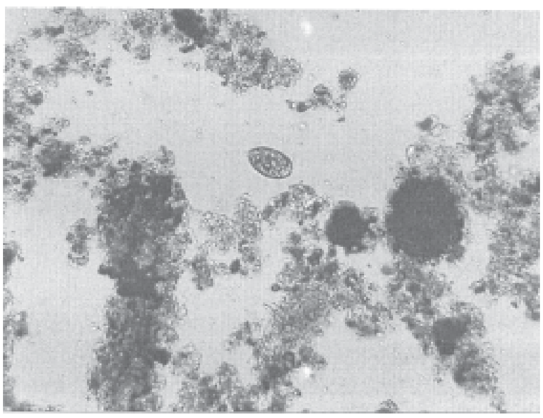

Fig. 3. The ciliates of Paramecium caudatum in the treating system with active biological sludge

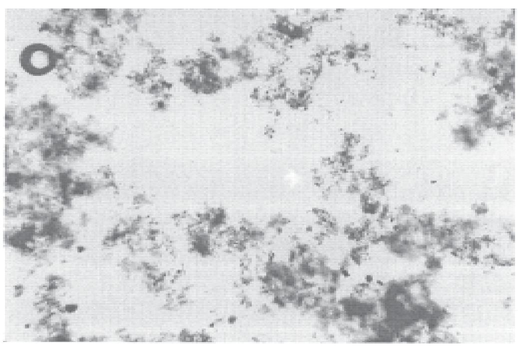

Fig. 4. The microscopic appearance of biological sludge in the treatment installation where activated carbon was added

The graphical representation for the biodegradation evolution of the contaminators from the two systems is shown in figure 2.

During the experiment the microorganisms living in the biocenosis sludge were not disturbed by the presence of the active carbon and the efficiency of removing the cotaminators was bigger than in the case of using the classical system.

The microscopic appearance of the biological sludge after treating the water contaminated with industrial contaminators is shown in fig. 3 and 4.

Ciliate *Paramecium sp.* multiply, is active, *Vorticella microstoma* is present and *Litonotus setigerum* is not affected by the presence of activated carbon and the mass Zooglea branches out to form a well defined homogeneous hifa. *Nostoc and Anabena*, filamentous bacteria are present which indicates an active biocenosis, microorganisms that are indicators of biodegradable wastewater. The efficiency of removing the contaminators using added carbon active was with up to 50% bigger than in the cassical method with biological sludge (fig.4).

Conclusions

The use of active carbon together with the biological sludge is a more efficient method to eliminate the contaminators from the wasted water in comparison with the classical system using biological sludge. Through the enrichment of the growth medium of biocenosis with powder of active carbon it is possible to absorb the contaminators on the sludge and thus to optimize the efficiency of the absorbtion process and biodegradation of the contaminators.

Activated carbon does not influence negatively the evolution of biological microorganisms from the biological sludge and is the promoter of the growing volume of biological sludge in the water treatment plants. The activated carbon is unifying the diffusion of oxygen in the biological sludge flakes and its adsorption on the surface of the flakes which increases the efficiency for the biodegradation of the contaminators from the waste water. The results of the experiments conducted to removing the contaminators from the polluted environments with industrial waste, led to the idea that the use of micro-organisms to biodegrade these contaminators is a more efficient method when the active carbon is added in the biological medium. Through the gradual introduction of pollutants in the sludge biological treatment system, the formed biocoenosis adapt to the new conditions of life and can biodegrade the introduced contaminators.

In order to avoid the inconveniences appeared due to the big variations for the concentration of the contaminators resulted from the technological process in the oil industry, should be used methods to store the wasted water in special reservoirs, then the stored wasted water must be pumped in small amounts towards the water treatment plant in order to be treated in the biological phase.

References

1.SUZULU, M., D. M. MISIC, 0. KOYAMA, K. KAWAZOE, Chem. Eng. Sci., 33, 271, 1978

2.TORRENTS, A,, R. DAMERA,0. J. HAO, J. Hazard Mat., 54, 141, 1997

3.WANG, R.-C., C.-C. KUO, C.-C. SHYU, J . Chem. Tech. Biotech., 68, 187, 1997

4.RISSE, AND H. SONTHEIMER, Co. and Engler-Bunte Institute of the University, Karlsruhe, Germany, 1979

5.SONTHEIMER, H., J. Am. Water Works Assoc., 71,618-622, 1979

6.VAN DER KOOIJ, D. In H. Sontheimer (ed.), 9, 348-354, EPA 600/9-76-030. U.S. Government Printing Office,Washington, D.C., 1976

7.WINKLER, K., K.-H. RADEKE, H. STACH, Chem. Tech. Leipzig , 48, 249, 1996

8.D. P. WILCOX, E. CHANG, K. L. DICKSON, K. R. JOHANSSON , Applied And Environmental Microbiology, 406-416, 1983

9.MAHMOUD M. Water ResearchVolume, 40, Issue 5, 1052-1060, 2006

10.GALLEGO, J. L. R., J. LOREDO, J. F. LLAMAS, Bioremediation, 12, 325, 2001

11.BEYCHOK, MR ISBN 8122415075, Chemical Engineering Progress Symposium Series 67, 107, 322-339, 1971

12.LARRY D., Ibis Publishing,1993

13.P. RAICU , Technical Printing House, 1990

14.KHOPKAR, SM , New Delhi: New Age International, 299, 2004

15.CHISTI,Y., Biotech. Adv., 6, 431-432, 2004

16.C.-Y. CHEN, J.-N. CHEN, S.-D. CHEN, Sci. Technol, 9, 139-143, 1999

17.J.J. MCCREARY, V.L. SNOEYINK, Water Res. ,14, 151–160, 198;0

18.R.-C. WANG, C.-C. KUO, C.-C. SHYU, J. Chem. Technol. Biotechnol, 68,187–194, 1997

19.S. HAYDAR, M.A. FERRO - GARCIA, J. RIEVERA-UTRILLA, J.P. JOLY, Carbon, 41, 387–395. 2003

20.DABROWSKI, P. PODKO´SCIELNY, Z. HUBICKI, M. BARCZAK, Chemosphere, 58, 1049–1070, 2005

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