

RESEARCH ARTICLE

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Modeling of biobasins of an oil refinery wastewater treatment plant

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Article info:

Received: 6 June 2014

Accepted: 13 November 2014

ABSTRACT

The biobasins of the largest wastewater treatment plant (WWTP) on the Balkans has been examined. Samples were taken four times from the inlet and outlet flow. The concentration of the total hydrocarbons, benzene, toluene, ethylbenzene, p-xylene, m-xylene, o-xylene and styrene in the wastewater has been obtained by gas chromatography. The average experimental concentrations were used when the mass balance was made. The results indicate that about 60% of pollutants are emitted in the air, about 22% are assimilated through biodegradation, and nearly 18% leave WWTP with the purified water. The measured concentrations were also modeled by Water 9.3 program. Comparison between the measured amounts of pollution concentrations and those forecasted by the Water 9.3 program has been made.

Key words: biobasins, wastewater treatment plant, mass balance, modeling

Introduction

The biobasins are the main and the most important part of an oil refinery wastewater treatment plant. The quality of the purified water is dependent mostly on its good performance. It would be fair if we say that biobasins are the heart of the WWTP. For this reason most studies concerning wastewater treatment plant (WWTP) and volatile organic contaminant (VOC) emissions from wastewater treatment plants have focused on aeration (or activated sludge) basins (Cheng & Chou, 2003; Atasoy et al., 2004; Chou & Cheng, 2005). Nikolaou et al. (2002) described analytical procedure for determination of volatile organic compounds, including methodology for taken of samples.

The material balance is basic method for exploring the performance of any equipment. The application of this method requires all possible mechanisms of leaving and transforming of the available pollutants in the waste water to be known (Tansel & Eyma, 1999). Those mechanisms of pollutants escape in the biobasins of a WWTP are the following:

- Evaporation (emission) – unrestrained process which occurs in accordance with the basic laws of mass transfer. This mechanism is fundamental and limits the basic part of migration process.
- Biodegradation – a process of biological break down of organic compounds to carbon dioxide, methane and water; this process is possible only if suitable conditions are available, for example - pH, temperature and nutrients, which stimulate the biological growth of microorganisms.
- Adsorption – the physical adsorption of the organic compounds on the active sludge. This mechanism is happening in a very small scale and is considered of no importance.
- Chemical reaction – it is possible only when chemical treatment is applied on wasted waters, or when there are present independent chemical compounds in the waste water reacting.
- Leaving with the outlet water flows – this process is relevant for those chemical substances which after treatment do not go through chemical or biological transformation, do

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not evaporate and leave the system as fraction of the purified waters.

- Other possible mechanisms – oxidation and hydroxyl radical reactions.

The largest WWTP of the Balkans has been built in the Bulgarian near the town of Burgas. It is owned by “LukOil Neftohim-Burgas” Company.

The aim of the present work was to examine the performance of the biobasins in WWTP of LukOil using the method of the material balance.

Materials and Methods

The completion of the mass balance was based on the acceptance that the basic mechanism of the leaving of the pollutants are evaporation (emission) from the open air surfaces, biodegradation and leaving with the purified water. The formulation of the mass balance was based on the admission that the basic mechanism of the pollutants leaving are emission from open water surfaces, biodegradation, and floating out together with outlet water streams. It was assumed that the process of adsorption, chemical reacting, and other possible mechanisms occur in a very insignificant extent in comparison with the basic mechanisms).

In the WWTP of LukOil there are 10 connected in parallel biobasins. Their parameters are shown in Table 1.

Table 1. Parameters of one biobasin

Length	80 m
Width	10 m
Depth	3.15 m
Area of agitation (each aerator)	100 m ²
Number of impellers	5
Power to impeller	29.5 hp
Diameter of impellers	2 m
Impellers speed	42 rpm

Table 2. Inlet and outlet biobasins concentrations of pollutants in g/m³

No	Compounds	Sample 1		Sample 2		Sample 3		Sample 4	
		C _{in}	C _{out}						
1	Total CH	16.80	3.00	36.30	1.20	27.60	1.20	10	1
2	Benzene	0.20	0.05	0.70	0.05	1.50	0.05	0.4	0.05
3	Toluene	0.60	0.05	0.70	0.05	1.70	0.05	0.7	0.05
4	Ethylbenzene	0.20	0.05	5.40	0.20	0.40	0.10	0.05	0.05
5	p-, m-, o-xylene	1.30	0.05	1.10	0.05	1.60	0.05	1	0.05
6	Styrene	0.20	0.05	7.30	0.30	1.40	0.10	0.3	0.05

Analysis of the samples

The analysis of the samples taken was carried out using a gas chromatograph Head Space 7694, Model HP 5890 with flame ionization detector, a column of 30 m length and a diameter of 0.53 x 2.65 mm. Helium was used as inert gas. The lower threshold of sensitivity of the chromatograph column used was 0.05 mg/l. The general content of hydrocarbons was defined, including the concentrations of benzene, toluene, ethylbenzene, xylene, styrene.

For the calculation of the material balance, the average experimental concentrations of inlet and outlet of the WWTP are used. The model of Mono was used for the defining of the portion of the pollutants, which have been assimilated through the biodegrading process. The model of Mono is implemented in the computer program Water 9.3, which has been used for this purpose.

Results

The results from the analysis of common hydrocarbons and individual aromatic hydrocarbons obtained are given in Table 2.

The results for the mass balance are given in Figure 1.

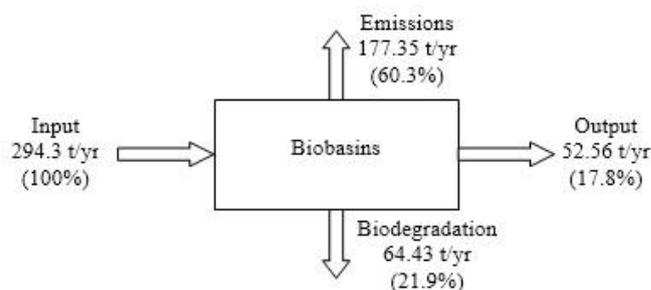


Figure 1. Material balance of the biobasins of WWTP.

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Discussion

The results given in Figure 1 show that the inlet waste water contain altogether 294.3 tons/annually pollutants. The emission of pollutants in the air has the biggest share – 177.35 t/yr (60.3%), 64.43 t/yr (21.9%) are eliminated through biodegradation, and about 52.56 t/yr (17.8%) leave the biobasins unchanged with the outlet water flow. It makes an impression that the share of the quantity of the emitted pollutants is considerably larger, about 3 times over from the share of biodegraded pollutants. Although, this must not lead to the conclusion that the biobasins work is not adequate. The vast amount of pollutants emitted is attributed to the active airing of the water by impellers. The process of airing is induced with the purpose of enriching the waste water with oxygen, essential to enable the aerobic process of the biodegradation. The process of airing of waste water is imperative – i.e. the large proportion of emitting of pollutants is generally correlated with the functioning of the biobasins. When discussing this study results we must understand that the biodegradation process is the only mechanism for efficient waste water treatment, a process, which destroy the toxin in real, without to contaminate the other components of our environment.

The comparison of the real emission amount and that calculated with Water 9.3 can be expressed with the following equation:

$$\varepsilon = \frac{E_{\text{exp}} - E_{\text{pred}}}{E_{\text{exp}}} \cdot 100$$

where ε – percent error, %; E_{exp} – experimental defined emission, t/yr; E_{pred} – emission predicted by the computer model Water 9.3, t/yr.

The results indicate that regarding the common hydrocarbons' emissions, the program Water 9.3 is about - 22.3% in error. The minus indicates that the forecasted quantity of emitting is larger than the calculated.

Acknowledgement

This study is part from a larger investigation, supported by “LuckOil Neftochim” Burgas (Contract NIS No14/2005).

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