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PURIFICATION OF BURGAS LAKE THROUGH ZEOLIT TYPE CLINOPTILITY

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Abstract: *This study investigates possibilities of natural zeolite as effective adsorbent of different pollutions in Burgas lake. Mathematical models to calculate the required amount of zeolite are applied. The following indicators were determined: A - calculation of the approximate water volume of Burgas lake, B - determination of total water amount contaminated by discharge sources, C - pollution of the water body, D - calculations for the required amount of zeolite as adsorbent per year.*

It was theoretically determined that water volume of Burgas lake is approximately 46 800 000 m^3. The total amount of polluted water of 46 345 813 m^3/year was calculated. Therefore, the whole water volume is replaced annually. The chemical characterization and qualities of Burgas lake depends of discharging of different industrial pollutants. The total theoretically amount of water pollutions is 7000 t/year. Required quantity of natural zeolite type clinoptilolite to maximum adsorption of available contaminants in Burgas lake of 35000 t/year was determined.

Keywords: *Zeolite, Water purification, Burgas lake..*

INTRODUCTION

Burgas Lake as a part of Burgas Water Area is announced to the largest natural lake in Bulgaria after Mandra dam construction in 1963 (Karayotov, I., and all, 2011). Its length is about 9.6 km, the width is about 2.5 up to 5 km, surface area of 28 km^2, and the water depth achieved up to 1.3 m (URL:https://www.bg.wikipedia.org.). Burgas Lake is surrounded by the second largest city on the Black Sea coast, which is an important industrial, trading and transport center. The intensive use of pesticides and fertilizers in the Burgas agricultural areas leads to pollution and increased process of eutrophication on the lake (Ptizite v Balgaria, 2012). Continuous lake pollution leads to almost complete extermination of the animal world. The lake is contaminated by petroleum products, phenols and other chemicals. The water quality assessment and the annual monitoring data indicate for the self-cleaning ability of the lake as well as of the ecological equilibrium and the rate of water pollution.

EXPOSURE

The following calculations to solve problem with ecological status and determination of rate of contaminated lake water are made:

A - calculation of the approximate water volume of Burgas lake,
B - determination of total water amount contaminated by discharge sources,
C - pollution of the water body,
D - calculations for the required amount of zeolite as adsorbent per year.

A - calculation of the approximate water volume of Burgas lake

The total water volume is determinate by applying of statistical mathematical models using geometric dimensions of satellite map. It was assumed that the lake has a shape of a rectangular parallelepiped, Fig. 1 as the formula for volume is follow:

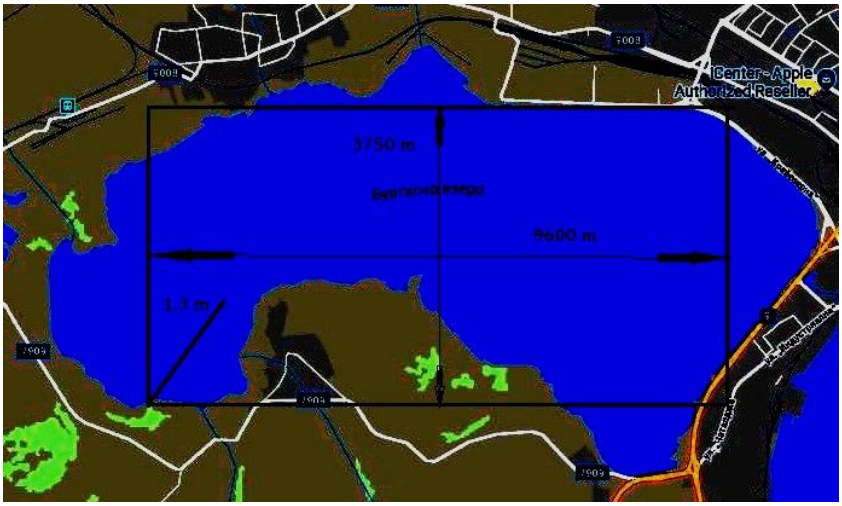

Fig. 1. Burgas lake (approximate dimensions of the water body)

$$V = A.B.C \quad (1)$$

when:

A, B - the length of sides of the base of rectangular parallelepiped,

C - the height of rectangular parallelepiped

The Burgas Lake dimensions according the references are following: average length (A) of 9600 m, average width (B) of 3750 m, and depth (C) of 1.3 m. It was theoretically determined that water volume of Burgas lake is approximately 46 800 000 m^3. It is approximate water amount of the pond and it varies according to the season.

B - determination of total water amount contaminated by discharge sources

Total contaminated water volume from discharged sources is the amount exhausted in Burgas lake from 5 different industrial source every year. It is the maximum limit of pollutants, but the volume would be exceeded.

Organized industrial discharge (source 1) - 2 316 245 m^3 /year

Organized industrial discharge (source 2) - 240 000 m^3 /year

Organized industrial discharge (source 3) - 7 200 m^3 /year

Organized industrial discharge (source 4) - 10 400 m^3 /year

Organized industrial discharge (source 5) - 43 771 968 m^3 /year

The amount of total wastewater is 46345813 m^3/year and the ratio total contaminated water to total clean water in the pond is 93.5% which indicates that the wastewater is equal to the total amount of water in the lake.

The theoretical calculations present that industrial discharge source 5 is the most pollutant and limit concentrations of contaminants, rate and annual contribution of wastewater discharged in Burgas lake are shown in table 1.

Table 1. Industrial discharge source 5 - limit concentrations of contaminants, rate and annual contribution of wastewater.

Contaminants	Rate of contaminants	Annual contribution of wastewater
BOD5	25 mg/dm-3	1,094 t/year
COD	125 mg/dm-3	5 471 t/year
Arsenic	0,05 mg/dm-3	2,2 t/year
Lead	0,05 mg/dm-3	2,2 t/year
Chromium (hexavalent)	0,05 mg/dm-3	2,2 t/year
Chromium (trivalent)	0,5 mg/dm-3	22 t/year
Mercury	0,001 mg/dm-3	0,043 t/year
Nickel	0,2 mg/dm-3	8,7 t/year
Zink	5,0 mg/dm-3	218,8 t/year
Cadmium	0,01 mg/dm-3	0,43 t/year
Copper	0,1 mg/dm-3	4,3 t/year
Phenol	0,05 mg/dm-3	2,2 t/year
Cyanides	0,5 mg/dm-3	22 t/year
Petroleum products	0,3 mg/dm-3	13,1 t/year

Annual contribution of pollutant in the Burgas lake discharged from industrial source 5 is 5 770.2 t/year. The amount is calculated based on Table 1.

C - pollution of the water body

The contamination of Burgas Lake in 2010, 2013, 2015, 2016 years is presented in Figures 1, 2, 3 (godisni dokladi na RIOSV Burgas za 2010, 2013, 2015, 2016 years).

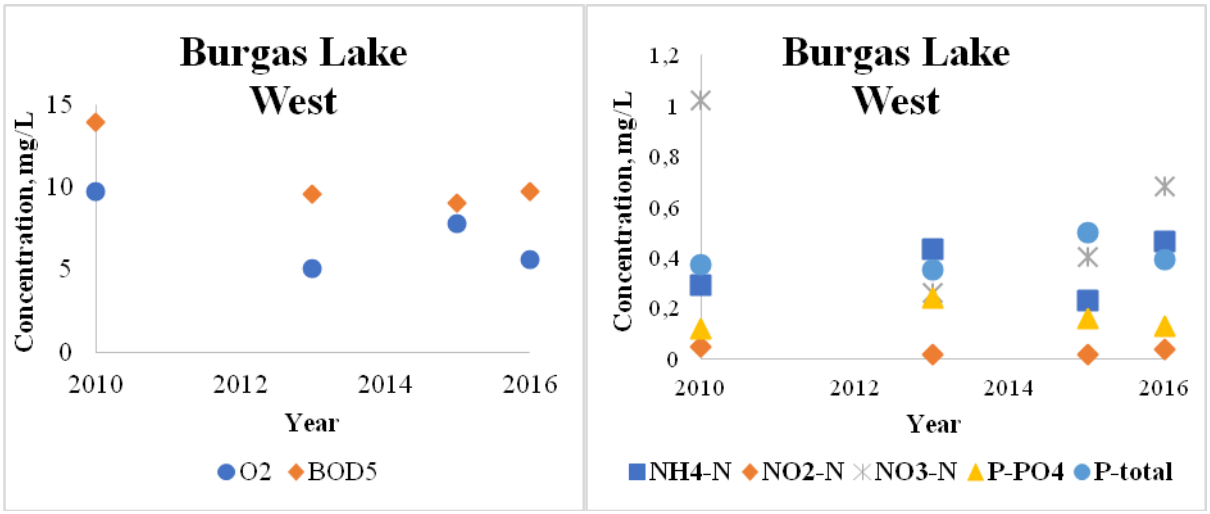

Fig. 1. Concentration of oxygen, BOD_5, NH4-N, NO2-N, NO3-N, P-PO4, P-total in Burgas Lake - West

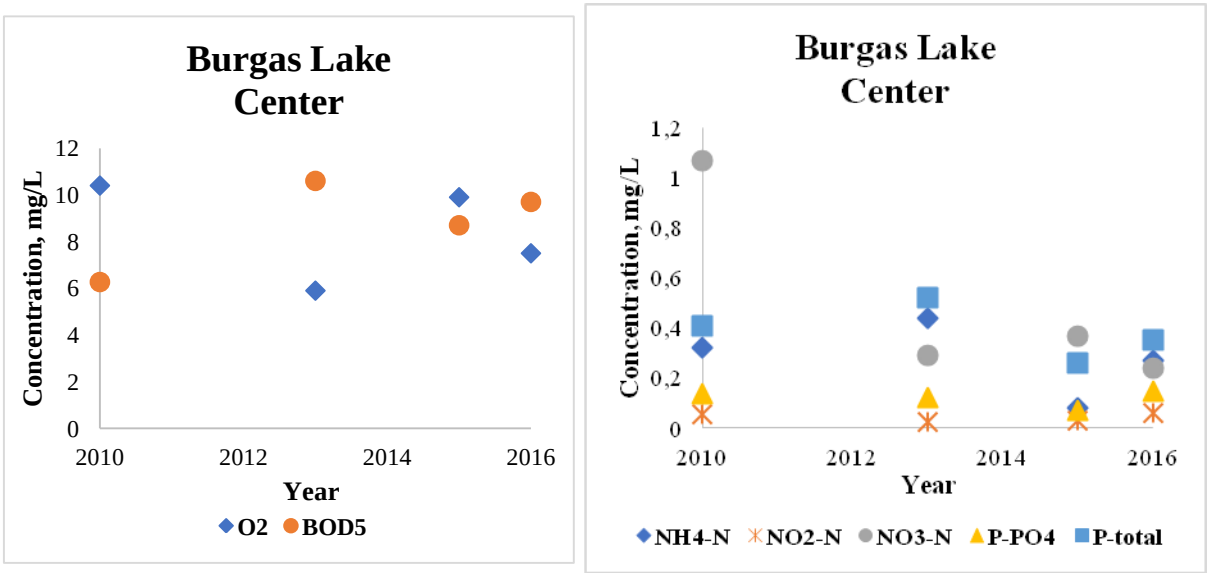

Fig. 2. Concentration of oxygen, BOD5 , NH4-N, NO2-N, NO3-N, P-PO4, P-total in Burgas Lake - Center

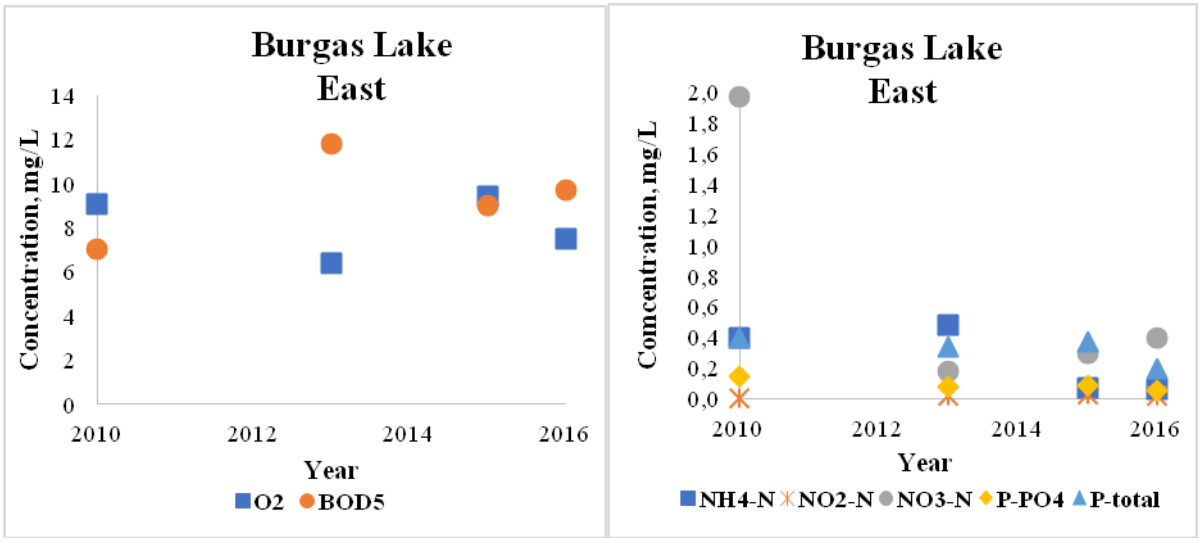

Figure 3. Concentration of oxygen, BOD5 , NH4-N, NO2-N, NO3-N, P-PO4, P-total in Burgas Lake - East

The figures show that the limit concentrations of pollutants are not exceeded, but It's not tendency in decreasing of contaminant. It indicates that the self-purifying effect of the lake is exhausted. If the adsorbent zeolte type of clinoptilolite obtained by Beli Plast, Bulgaria would be applied, the self-purifying effect of the lake will improve. It is a low-cost broad-spectrum adsorbent in powder form.

D - calculations for the required amount of zeolite as adsorbent per year

In Bulgaria, the zeolite type of clinoptilolite is extracted from a deposit in the Rhodope Mountains, Beli Plast. The adsorption capacities of different pollutants and the absorption values of zeolite of clinoptilolite type are shown in Tables 2, 3, 4. The annual contribution of the pollutants is 5 770.2 t /y. is calculated applying data from table 1 in case of a total annual contribution of pollutants and acceptable tolerance of 20% then quantity of contaminants of 7000 t /y is obtained and it would be adsorbed by a zeolite type of clinoptilolite. The required zeolite is 35 000 t/year after applying the mathematical calculation using of allowable excess of the adsorbent to be achieved 100% adsorption of pollutants per year or 2916 t/month respectively. The amount of 1458

tons per month or 50 % zeolite would be enough to be applied as adsorbent because of lower concentrations of contaminates below the limit levels.

Table 2. Adsorbtion capacities of zeolite type of clinoptilolite (Mihalev T., **(**2014),)

Contaminates	Adsorption capacity	
Manganese ions	71,0	mg/g
Ammonia ions	61,5	mg/g

Table 3. Adsorbtion capacities of zeolite type of clinoptilolite (Benev D., 2011)

Contaminants	Adsorption capacity	
Cu(II)	7 - 8	g/kg
PO^{3-}	61,5	g/kg
Petroleum products	99,5	%
Phenol	9,9	g/кg

Table 4. Adsorbtion capacities of zeolite type of clinoptilolite (Mihalev T**.**, Markovska I., Yaneva S., 2016)

Contaminants	Adsorption capacity	
COD	20,1	%
BOD_5	26,5	%
Fats	41,5	%

CONCLUSIONS

It was theoretically determined that water volume of Burgas lake is approximately 46 800 000 m^3. The total amount of polluted water of 46 345 813 m^3/year was calculated. Therefore, the whole water volume is replaced annually. The chemical characterization and qualities of Burgas lake depends of discharging of different industrial pollutants. The total theoretically amount of water pollutions is 7000 t/year. Required quantity of natural zeolite type clinoptilolite to maximum adsorption of available contaminants in Burgas lake of 35000 t/year was determined.

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