UDK 574.63(045)

A.V. Yakovleva[1], O.O. Vovk[2], N.A. Shevchuk[2]
[1]National aviation university, Kiev, Ukraine
[2]National technical university of Ukraine “KPI”, Kiev, Ukraine

EFFECTIVE MICROORGANISMS TECHNOLOGY APPLICATION IN MUNICIPAL WASTEWATERS TREATMENT PROCESS

This article is devoted to the problem of municipal waste waters purification. The present day situation with waste water treatment facilities in Ukraine, existed methods of waste waters purification and search for new ones are described. Modern problems of wastewaters treatment process is discusses on the example of the Bortnichy station of aeration in Kiev. A comparatively new method of sewage waters purification from organic and microbial contaminants is presented. Possibilities to apply this method at the Bortnichy station of aeration are discussed in the article.

Дана стаття присвячена проблемі очистки міських стічних вод. В ній описано ситуацію, що склалася на сьогоднішній день в Україні з очисними спорудами, їх теперішній стан; розглянуто вже існуючі методи очистки стічних вод та можливість пошуку нових. Сучасні проблеми пов’язані з процесом очистки стічних вод розглянуто на прикладі Бортницької станції аерації м. Києва. Запропоновано порівняно новий метод очистки міських стічних вод від органічних та мікробіологічних забрудників. В статті розглядається можливість його застосування на Бортницькій станції аерації.

Данія статья посвящена проблеме очистки городских сточных вод. В ней показано ситуацию, сложившуюся на сегодняшний день в Украине с очистительными сооружениями, их теперешнее состояние; рассмотрено уже существующие методы очистки сточных вод и возможность поиска новых. Современные проблемы, связанные с процессом очистки сточных вод рассмотрено на примере Бортнической станции аэрации г. Киева. Предложено сравнительно новый метод очистки городских сточных вод от органических и микробиологических загрязнителей. В статье рассматривается возможность его применения на Бортнической станции аэрации.

Nowadays one the most important ecological problem of Ukrainian cities is the state of municipal sewage waters treatment systems. Almost in all cities of Ukraine wastewaters treatment facilities are old and need general reconstruction. As a result many treatment facilities have problems with unpleasant odors and low quality of dumped drains. As it is known, the parameters of portable water used in Kiev are unsatisfactory. It possesses unpleasant smell and taste. Citizens use this water only for some household needs. More often for drinking and cooking they either use water from underground sources, either buy specially cleaned water or at least use water filters. It generates environmental problems that are widely discussed by the population and the authorities as well.

All wastewaters from Kiev and 13 nearby towns are treated at the Bortnichy Station of Aeration. Here municipal and industrial wastewaters are processed. The complex consists of 3 treatment blocks. Fist started to work in 1965, second in 1976 and third in 1987. Here municipal and industrial wastewaters are processed. Capacity of the station is 1,8 mln cubic meter/day. Daily volume of influent is about 0,8 – 1,0 mln cubic meters. Total area of 3 mud fields is 272 ha. Purified water is damped into the Dnieper River through the main channel. Technological process includes mechanical treatment and biological treatment.

Unfortunately exploitation of the BSA is connected with the number of problems. Technological scheme of the station is very old (it was projected in 1950-1960’s). Since that time there were no significant modernizations and reconstructions. But the number of population has grown in several times and the character of waste has changed. Metal and concrete constructions,

technological pipelines, pumping equipment are constantly damaging and need repair or complete replacement. Spaces in bar screens are equal to 16 mm and they are too large. They don't provide the required level of purification, so big-size pollutants get to the next stages of sewage treatment, and causes further damage of equipment.

Another problem is absence of effective technology for sludge disposal. Real volume of sludge stored at 3 mud fields is about 9 mln m^3 what in 3 times higher that it was projected. Before 1985 mud was being dried, then transported to agricultural territories and used as a fertilizer. However it was found an increased concentration of heavy metals in sludge and such application of mud was prohibited. So now mud fields are used not only for sludge dehydration as it was projected but for it storage also. So, today we have a problem of mud fields overfilling. The temporary measure to prevent dams breakthrough and mud spillage is increasing of dams height. But for the moment even such measure is not done completely. A cardinal solution for this problem is building of mud combusting plant.

Accumulation of waste in settling tanks, causes methane and hydrogen sulfide gas formation and as a result unpleasant odor distribution, especially in summer. This cause constant complains from population living in the vicinity of the BSA.

One more problem is purification from biogenic elements – nitrogen and phosphorous compounds. Constant growth of these elements concentration in purified water is observed. So, there is a need in modern technologies implementation for overcoming this problem. However all abovementioned problems are a result of insufficient or sometimes total absence of financing.

In our research we propose to apply a comparatively new method of wastewater treatment known as EM-technology at the BSA. EM (short from Effective Microorganisms) was created in the University Rjukjus, Okinawa, Japan in 1970's by Professor Teruo Higa. Initial purpose of his investigations was to increase quality of agricultural products without use of chemicals. During numerous researches T. Higa defined that some groups of microorganisms lately named as effective positively influence on fruits and vegetables quality. In numerous countries EM are successfully applied in agriculture, processing of waste, bioremediation, public health services and many other spheres of human activity. For about 10 years EM is applied for wastewaters treatment. However there is still no such experience in Ukraine.

Actually EM represent a liquid with pH = 3,5 or lower. It is a mixture of various groups of naturally living in the environment useful, not pathogenic, aerobic and facultative anaerobic microorganisms consisting basically from phototrophic and lactic bacteria and yeast.

According to the patent registered in the USA EM consists of the following groups of microorganisms: Actinomycetes *(Streptomyces albus, Streptoverticilliu baldaccii, Nocardia asteroides, Micromonospora chalcea, Rhodococcus rhodochrous),* Phototrophic bacteria *(Rhodopseudomonas sphaeroides, Rhodospirillum rubrum, Chromatium okenii, Chlorobium limicola),* Lactic bacteria *(Lactobacillus bulgaricus, Propionibacterium freudenreichii, Pediococcus halophilus, Streptococcus lactis, Streptococcus faecalis),* Mold fungi *(Streptomyces albus, Streptomyces griseus, Aspergillus oryzae, Mucor hiemalis),* Yeast *(Saccharomyces cerevisiae, Saccharomyces lactis, Candida utili).*

The density of the above-stated microbiological cultures in EM which there it is totaled nearby 80, can change within the limits of from 10^4 up to 10^8 CFU/ml. The specified cultures represent group of useful microorganisms which can coexist in the same conditions.

Basing on investigations of T. Higa, EM Research Organization and experience of countries, which successfully use mentioned technology for sewage treatment we came to conclusion that EM may show positive results in reduction of the following parameters of water contamination: BOD, COD, Nitrogen and Sulfur compounds, suspended solids content, sludge volume and bacterial analysis.

Speaking about the quality of sewage is necessary to consider physical-chemical composition of wastewaters processed at the BSA. Table 1 presents average monthly values of pollutants in effluent (purified) waters in January 2011. Values in influent (polluted) waters and limit acceptable concentration of pollutants are also presented in the given table. Experiments are executed by

chemical-bacteriological laboratory of the BSA. Limit acceptable concentration of parameters are regulated by the normative document СанПиН №4630-88 “Protection of surface waters from pollution”. Concentration of pollutants in effluent waters is regulated by the normative document “Limit acceptable damp of substances with effluent waters from Bortnichy station of aeration, which are adopted by State agency of ecology and natural resources in Kiev city from 01.01.2009”. As it is clearly seen almost all parameters except BOD, COD and phosphates concentration don’t exceed norm. However, it is explained by multiple dilutions of effluent with fresh water from the Dnieper River.

Table 1

Physical-chemical composition of wastewaters processed at the BSA

Index		Influent water	Effluent water	LAC in surface waters
Temperature		18 ^{o}C	16 ^{o}C	
pH		7,4	7,4	6,5 – 8,5
Suspended particles		373 mg/l	11,9 mg/l	+0,75 to the background
Chlorides		88,6 mg/l	84,5 mg/l	350 mg/l
Sulfates		62,4 mg/l	55,0 mg/l	500 mg/l
BOD_5		312 mg/l	9,1 mg/l	6 mg/l
Diluted oxygen		-	5,51 mg/l	Not < 4 mg /l
COD		621 mg/l	61,3 mg/l	30 mg/l
Phosphates		17,99 mg/l	5,27 mg/l	3,5 mg/l
Nitrogen group	Ammonia salts	31,5 mg/l	1,37 mg/l	2 mg/l
	Nitrites	undetermined	1,45 mg/l	3,3 mg/l
	Nitrates	-	25,3 mg/l	45 mg/l
Copper		0,064 mg/l	0,012 mg/l	1,0 mg/l
Zinc		-	-	1,0 mg/l
Chrome		0,038 mg/l	0,003 mg/l	uncontrolled
Iron		1,90 mg/l	0,25 mg/l	0,3 mg/l
Oil products		1,26 mg/l	0,05 mg/l	0,30 mg/l
Surface active substances		1,31 mg/l	0,04 mg/l	0,50 mg/l
Bacterial analysis	General microbic number	951800	7934	
	Coli-index	$19*10^{7}$	$17*10^{5}$	

As it was mentioned there is no experience of EM-technology application for wastewaters treatment in Ukraine. But EM are successfully used in Jefferson City (USA) for municipal wastewaters treatment. In our research we analyzed the number of parameters, which characterize treatment process in Jefferson City and Kiev. Among these parameters are: geographical position of the cities, climatic conditions, number of population, physical-chemical composition of waste, volume of waste processed, technological systems of treatment process. As a result we came to conclusion that abovementioned parameters are pretty much common and American system should be quite well adoptable to existing system of wastewaters treatment at the BSA. Jefferson City Wastewater Treatment Facility is 35 years old and its main problems are odor control and high level of water pollution. Instead capital reconstruction of the treatment facility it was decided to apply microbial EM-technology.

Big volumes of EM preparation are necessary for sewage purification at treatment plant. For this purpose the Mobile Production Unit (MPU) is designed. According to recommendations given by EM Research Organization amount of EM that should be introduced into treatment system is 1:10 000 of daily sewage volume that comes into treatment plant.

EM preparation is introduced into several collecting points of municipal drains around the

city. At the treatment plant EM preparation is introduced in 2 points: in aeration tank and secondary settling tank. EM preparation is not introduced constantly. The largest portions should be input before and right after peaks of sewage income. The portions should be spent at midnight. It allows EM to dominate in sewage stream within all night when activity of anaerobic microbes making fetid sulphides raises. In some time colonies of microorganisms begin to populate in water stream, pipelines and reservoirs internal surfaces. Surfaces of some equipment become colored in reddish brown. Water in reservoirs become more transparent, filters in equipment cleaner and doesn't have a strong odor.

Basing on experiments and data we can predict the following positive results in such microbial technology application:

- Lower primary sludge production and a lower dry matter content of sludge in the aeration tank;
- Sludge volume production decreases up to 60-65%;
- The average chemical oxygen demand (COD) level after clearing can make up to 40 %;
- The average nitrogen level decreases on 25-30%;
- Reduction of ammonia concentration is up to 85%;
- Reduction of unpleasant odors level;
- Reduction of Coli bacillus containing in excrements during EM application can make up to three times;
- The average sulfides level of removal can decrease up to 70 %.

The advantages of microbic cultures introduction into wastewater treatment process are: hhigh efficiency of the method, comparatively low cost, simplicity in use, possibility to apply in a small communities and in a big cities, natural method of sewage treatment, absence of high operational expenses, ecological compatibility and safety. The only disadvantage of microbic cultures introduction into wastewater treatment process is insignificant growth of sulfates.

The city waste water pollution leads to the great number of problems connected with a citizens health and with the environment itself. Our research is devoted to investigation of new methods and technologies for water purification from biological pollutants. Analyzing the principle of EM-technology application in other countries we came to conclusion that it can be also used in our country. Implementation of EM may show such results: lower sludge production, lower COD, lower concentration of nitrogen and ammonia concentration in clarified water, what in its turn overcomes the fetid smell problems.

In view of all abovementioned we consider that EM implementation to the BSA may improve ecological parameters of influent waters and the Dnieper river in general.