ANNOTATION

to the dissertation work of the dissertant **Syzdykova Marzhan Nurlanovna** on the topic «The use of chemotrophic microorganisms for the treatment of organic-containing wastewater of the enterprises of the city of Shymkent» for the degree of Doctor of Philosophy (PhD) on the educational programme 8D05210- «Ecology»

Relevance of the topic. Approximately 410 billion cubic metres of wastewater is generated globally each year. Due to wear and tear of equipment or lack of treatment systems, a significant part of water used in industry is discharged into the environment without proper treatment.

Kazakhstan is among the countries with a high degree of water scarcity. Currently, about 50 per cent of wastewater is discharged into surface water bodies of the country without preliminary treatment. This situation is related to the use of imperfect wastewater treatment technologies at most processing and energy enterprises of the Republic. In some regions, treatment facilities have been in operation for a long time without modernisation. This poses a serious threat to aquatic ecosystems, the environment and public health. Over the last decade, the volume of industrial and domestic wastewater in the country increased from 3594.11 million m^3/year to 6039.00 million m^3/year, while the volume of treated wastewater increased from 525.1 million m^3/year to 662.2 million m^3/year. This means that only about 11 per cent of wastewater is treated.

According to the Bureau of National Statistics, in Shymkent city, out of 81 million m^3/year of supplied water, only 37 million m^3/year passed through treatment facilities, which is 45.6 %.

To date, several methods of wastewater treatment are known. Mechanical (filtration, sedimentation, centrifugation, sieving), physico-chemical (sorption, aeration, extraction, coagulation, flotation, electrolysis, ion exchange, crystallisation) and biological treatment methods (biofilters, oxitanks, aerotanks, submersible biofilters, anaerobic biofilters) are used to treat water contaminated with organic compounds. To date, biological treatment has been recognised as environmentally safe and effective. The main mechanisms of biological wastewater treatment are sorption, extraction, utilisation of pollutants in metabolic processes and other methods.

The biological treatment process usually uses a set of different groups of microorganisms or activated sludge, which are able to purify water from pollutants by 85%. Heterotrophic microorganisms such as *Pseudomonas* and *Zooglea* bacteria and the microalgae *Chlorella vulgaris KAI* and *Oocystis borge ATP* form the basis of such biocenoses. The role of these microorganisms in the water treatment process is well understood.

However, the role of autotrophic microorganisms in wastewater treatment has not been sufficiently investigated to date. It is known that autotrophic microorganisms cannot utilise organic compounds in their metabolic processes, but

they can participate in these processes indirectly - by excretion of various metabolites**.**

Purpose of work: Research of possibilities of application of chemotrophic microorganisms for treatment of wastewater with organic pollution, formed at the enterprises of Shymkent city.

Main objectives of the study:

- Study of physico-chemical characteristics of wastewater of Shymkent city enterprises;
- Study of microflora of organic-containing waste water of Shymkent city enterprises;
- Determination of the role of chemotrophic microorganisms in the process of wastewater treatment.

Objects of the study. Communal and domestic wastewaters of 'Su Resourcestars - Marketing' LLP of Shymkent city, wastewaters of 'Petro Kazakhstan Oil Products' LLP containing oil and oil products, as well as pyrophoric iron sulfides formed at the stage of cracking at the oil refinery 'PetroKazakhstan Oil Products', bacterial strains *Acidithiobacillus ferrooxidans Ach1* and *Acidithiobacillus ferrooxidans BIT1*.

Research methods. Hydrochemical analysis of wastewater samples was carried out in accordance with GOST requirements. COD and BOD indicators of water were determined by standard methods. Transparency, colour and odour of wastewater were determined by organoleptic method. The fat content of wastewater was determined by gravimetric method. The isolation and cultivation of thionic bacteria was carried out by the method of limiting dilutions. Activity of thionic bacteria was determined by trilometric method. The spectrophotometric method was used to determine the degree of Fe^{2+} oxidation in the bacterial suspension. A polarimetric method was used to determine the degree of purification of the model solution. Fe^{2+} and Fe^{3+} content was determined by the complexometric method.

Tauda, Mikmed-5, Biomed and OLYMPUS BX51 microscopes were used in microscopic studies. At neutralisation of pyrophoric iron sulphides the raw materials were investigated using mass spectrometer with inductively coupled plasma; determination of elements was carried out according to ST RK ISO 17294-2-2006.

Methods of synthesis, analysis and generalisation of research results, statistical data, experimental evaluations, physico-chemical and engineering-ecological surveys were applied during the work. Analyses were performed in regional laboratories. All experiments were carried out in threefold repetition, standard deviation was calculated at $0.91>P>0.85$. Statistical processing of data was carried out on Pentium-IV PC using Microsoft Excel statistical software package.

The main points put forward for defence:

1. Physico-chemical and microfloral characteristics of municipal and domestic and oil-containing wastewater of Shymkent city were specified, as well as the efficiency of biocoagulation treatment of these waters was determined.

2.It was established that the process of biological oxidation of divalent iron by *A. ferrooxidans Ach 1* strain is influenced by the temperature regime; the optimal temperature is +30 +35 °C.

3.At purification of the model solution containing dairy products, the efficiency of application of *A. ferrooxidans* suspension as a biocoagulant in concentration of 40.0 ± 5.0% was confirmed experimentally.

3.To reduce the COD indicator in the refinery wastewater containing detergents to a maximum of 88.1 ± 7.9%, the optimal dosages of trivalent iron (obtained by bacterial-chemical method) and bentonite were established, and the optimal conditions for cultivation of *A. ferrooxidans* strain in solutions containing pyrophoric iron sulfides were determined.

The main findings of the study are:

1. Physico-chemical characteristics of wastewater of municipal and domestic sector and oil refinery enterprise of Shymkent city were specified. At treatment of municipal wastewater using bacterial suspension *A. ferrooxidans* the degree of removal of pollutants was: oil products - 95.1 ± 0.5%, ammonium nitrogen - 57.5 ± 0.5%, phosphates - 73.7 ± 0.5%, fats - 60.0 ± 0.5%, phenol - 75.0 ± 0.5%. After biocoagulation treatment of oil refinery wastewater, the content of oil products decreased by 89.8 ± 0.5%, suspended solids - by 24.1 ± 0.1%, COD - to 69 ± 0.5%, the degree of phenol removal reached 73.3 ± 0.3%. Wastewater microflora is mainly represented by protozoa, in particular infusoria, as well as algae. On the basis of the research results, the technological scheme of wastewater treatment for these enterprises was developed.

2. In the course of experiments a significant influence of temperature factor on biological oxidation of divalent iron by microorganisms was established. During iron oxidation by *A. ferrooxidans Ach 1* strain at +30 +35 °C the Fe^{2+} content decreased from 10 ± 0.1 g/l to 1.6 ± 0.1 g/l in 2 days, which corresponds to a sixfold decrease. At +10 °C, iron concentration decreased to 1.0 ± 0.1 g/l in 3 days. The maximum oxidation rate of Fe^{2+} to Fe^{3+} was 0.5 ± 0.1 g/L per hour.

3. When a model solution containing dairy products was purified using *A. ferrooxidans Ach 1* as a biocoagulant, the purification rate reached 92.5 ± 0.5% and the water clarity increased to 80.0 ± 3.5%. The biocoagulation process lasted for 6 minutes.

4. To reduce COD in oil refinery wastewater containing detergents, the effectiveness of bacterial-chemical method in combination with bentonite was confirmed. According to the results of mathematical modelling, the maximum reduction of COD index (88.1 ± 7.9%) was achieved using 1.75 g/l of bacterial-chemically produced trivalent iron in combination with 600.0 mg/l of bentonite. The optimal conditions for culturing *A. ferrooxidans* thione bacteria on solutions containing pyrophoric iron sulfides as a source of Fe^{2+} were also established: temperature +28 °C, pH 2.0-2.5, C:T ratio = 1:10 ± 2.

Justification of novelty and importance of the obtained results:

– For the first time, the optimal conditions for cultivation of *A. ferrooxidans* strain and its vital activity were established, and the rate of iron oxidation under different temperature regimes was determined. When divalent iron was oxidised by

A. ferrooxidans Ach 1 strain at +30 +35 °C, its concentration decreased from the initial 10 ± 0.1 g/l to 1.6 ± 0.1 g/l in 2 days, which corresponds to a six-fold decrease.

– The possibility of using bacterial suspension of *A. ferrooxidans Ach 1* as a biocoagulant for purification of a model solution containing dairy products was investigated and proved for the first time. With this method, the purification degree was 92.5 ± 0.5 per cent and water clarity increased to 80.0 ± 3.5 per cent.

– The trivalent iron obtained by bacterial-chemical method on the basis of *A. ferrooxidans* strain was applied for the first time for treatment of waste water of Shymkent city enterprises. Degrees of purification were: oil products - up to 95.1 ± 0.5%, ammonium nitrogen - up to 57.5 ± 0.5%, phosphates - up to 73.7 ± 0.5%, fats - up to 60.0 ± 0.5%, phenol - up to 75.0 ± 0.5%. After biocoagulation treatment of oil refinery wastewater, the content of oil products decreased by 89.8 ± 0.5%, suspended solids - by 24.1 ± 0.1%.

– For the first time the optimal conditions for cultivation of thionic bacteria *A. ferrooxidans* in solutions containing pyrophoric iron sulfides as the only source of divalent iron were determined. The optimal parameters are as follows: temperature +28 °C, pH 2.0-2.5, C:T ratio = 1:10 ± 2.

Theoretical and practical significance of the work.

As a result of the conducted experimental research the possibility of wastewater treatment of industrial enterprises and municipal and domestic objects with the use of chemotrophic microorganisms has been established. These results are confirmed by the act of pilot tests on the production base of «Water resources - Marketing» LLP of Shymkent city.

Physico-chemical characteristics of wastewater can be used in further studies and environmental organisations.

The results of microfloristic analysis of organ-containing wastewater of Shymkent city enterprises are proposed to be used in standardisation and certification of water resources quality.

Bacterial biocoagulant - suspension of *A. ferrooxidans* in concentration of 40.0 ± 5.0% - is recommended for practical application at the enterprises having organ-containing wastewater. The main consumers are enterprises of dairy, bakery, brewery and other food industries.

The results of the study can be used in the educational process in the educational programme «6B05210 – Ecology», as well as in practical and laboratory classes in the disciplines «Industrial ecology», «Wastewater treatment technology».

Correspondence of the dissertation to the directions of science development or state programmes.

The dissertation work was carried out within the framework of the research plan of the MB R&D21-03-04 ‘Sustainable development of the southern region of Kazakhstan and green technologies’ of the department ‘Ecology’ of M. Auezov South Kazakhstan University for 2021-2025, as well as within the framework of the grant №85/ЈҒ-5-24-26 of the Science Committee of the Ministry of Education

and Science of the Republic of Kazakhstan ‘Technology of treatment of organ-containing wastewater using chemotrophic microorganisms’ (2024-2026).

Doctoral student's personal contribution to the preparation of each publication.

On materials of the dissertation work 14 scientific works are published, from them 3 articles - in the journals included in database Scopus, 1 article - in the journal recommended by KN MES RK, and 10 articles - in collections of materials of the international conferences. 1 author's certificate was received.

1. In the article «Fe2(SO4)3 and bentonite use to reduce COD indicators in waste water containing detergents», published in the «Journal of Ecological Engineering», the author participated in the preparation of the review, data analysis, obtaining results, design and editing of the material in accordance with the requirements of the journal.

2. In the article «Use of Acidithiobacillus ferooxidans for Decontamination of Explosive Waste from oil refineries» (Journal of Ecological Engineering) - participation in conducting experiments, comparative analysis of data, processing and discussion of results.

3. In the article «Buffer Effects in Submersed Denitrifying Biofilter’» (Journal of Ecological Engineering) - preparation of a review, data analysis, obtaining and processing of results.

4. In the article «Ағынды суды тазалауда пайдаланылатын *Acidithiobacillus ferrooxidans Ach 1* бактериялық штамының темірді биохимиялық тотықтыру жылдамдығын зерттеу» (Journal of Vestnik of Shakarim University. Series of Technical Sciences) - direct participation in experiments, comparative analysis of data, design and editing of the article in accordance with the requirements of the journal.

Structure and scope of the thesis.

The dissertation of 123 pages includes an introduction, four chapters, general conclusions, a list of used literature containing 205 titles, and an appendix of 8 pages. The text of the work contains 30 figures and 19 tables.