International Journal of Design & Nature and Ecodynamics
Vol. 18, No. 3, June, 2023, pp. 661-668
Journal homepage: http://iieta.org/journals/ijdne

Isolation of New Strains of Microorganisms for Bio-Purification of Polluted Reservoirs of Northern Kazakhstan

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https://doi.org/10.18280/ijdne.180318

Received: 16 January 2023
Accepted: 2 April 2023

Keywords:
microorganisms, collection strains, biological purification, water resources, rivers of Kazakhstan

ABSTRACT

This study aims to explore the potential of new microorganisms for bio-purification of polluted reservoirs in Northern Kazakhstan. Through laboratory experiments involving field collection of hydrobiological samples and screening of new strains of microorganisms, the study suggests that biological purification using organic and inorganic compounds found in polluted waters as a nutrient medium is the most effective method. This research contributes to the development of effective strategies for addressing pollution in Northern Kazakhstan's water resources and highlights the potential of using microorganisms as a tool for environmental remediation. The significance of the research lies in the fact that it proposes a solution to the issue of pollution in reservoirs in Northern Kazakhstan through the introduction of new strains of microorganisms, contributing to the development of effective strategies for improving water quality and minimizing the negative impact of pollutants on the hydrosphere.

1. INTRODUCTION

Recently, the problem of pollution of water bodies with a waste of technogenic origin has become increasingly acute. Wastewater is discharged into reservoirs that are insufficiently purified from various industrial and infectious pollutants that adversely affect the health of people and animals. The existing water treatment technologies at water supply stations cannot cope with the ever-increasing anthropogenic pollution of water supply sources, as a result, the water area and soil are poisoned, having a detrimental effect on the living organisms. In most Common wealth of Independent States countries, including Kazakhstan, the chlorination method has been used for the last few years to disinfect water at water treatment plants using chlorine gas and its derivatives [1]. The main advantage of using this method is the high efficiency of chlorine products against the bactericidal action of microorganisms. However, conventional cleaning methods are ineffective, characterised by multi-stage, the complexity of the equipment used, and the limited raw material base used. The formation of organochlorine compounds, high toxicity, mutagenicity, and carcinogenicity of which can accumulate in organisms and tissues of aquatic organisms, causing their physiological changes and death in the environment. Nevertheless, the simplicity of the design and the possibility of operational control in case of deterioration of water supply and sanitation pipelines is undoubtedly an advantage of this method. Thus, the search and creation of new and effective materials for the breeding of microorganisms for the bio-purification of polluted water bodies in Northern Kazakhstan is an urgent task of theoretical and practical importance.

The use of microorganisms to prevent pollution of reservoirs was conducted by both Kazakh researchers [1-5] and researchers from other countries [6-10]. However, a single mechanism capable of protecting reservoirs from both exogenous and endogenous pollution has not yet been developed. Consequently, modern water purification technologies require the search for organisms that utilise pollutants as efficiently as possible and the construction of stable remediation cenoses to ensure a stable process of biodegradation of all pollutants synthesised by humans. Therefore, the use of biological methods of bioremediation of reservoirs, namely microorganisms-destructors of various pollutants is currently necessary, due to the deterioration of the environmental situation not only in the country but also in the world. Preference is given to highly efficient technologies that combine the advantages of biological methods in the struggle for effective purification from the pollution of water resources of Northern Kazakhstan. Under natural conditions, the vast majority of microorganisms live, multiply by attaching to the mineral particles of the bottom sediments of reservoirs, roots, or upper parts of plants. For that reason, pre-immobilisation of cells on insoluble carriers is usually used for the development of destructive microorganisms that are introduced into a polluted aquatic environment to ensure long-term vital activity in it.

Biological methods, such as bioremediation, can demonstrate efficiency in cleaning up water pollution by stimulating natural or laboratory-accumulated microorganisms to break down and metabolize pollutants in the water. This method is rational and urgent because traditional methods, such as chlorination, are becoming less effective in the face of increasing water pollution from industrial and infectious sources. Bioremediation can be a more sustainable and cost-effective alternative to traditional methods, as it utilizes natural processes and does not require the use of harsh chemicals. It also has the potential to restore ecosystems and promote biodiversity. Compared to traditional methods, biological methods have a lower environmental impact and can be tailored to specific pollutants and environments. However, they may require longer treatment times and careful monitoring to ensure effectiveness.

The work was conducted on the isolation, investigation of various biological properties of new bacterial isolates, and their identification. The most active strains can be considered in the future as a biological product for the destruction of various biogenic and organomineral pollutants during the purification of polluted natural waters. The study examined the data of the Information bulletin on the state of the environment of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 3(29) [2], according to which, in comparison with the 1st half of 2020, the quality of surface waters of the Akbulak, Sarybulak rivers has not changed considerably, the water quality of the Nura-Ishim canal has moved from above 5th class to 4th, the Ishim river from 4th class to above 4, in the Vyacheslav reservoir, the water quality has improved and moved from 3rd class to 2nd. The main pollutants of the water bodies of the Astana and Akmola region are total phosphorus, calcium, magnesium, chlorides, mineralisation, sulfates, total iron, chemical oxygen demand.

The purpose of the study is to obtain new strains of microorganisms and conduct screening of the most active bacteria with the ability to destroy various pollutants for the bio-purification of polluted reservoirs in the Northern region of Kazakhstan.

The article discusses the problem of water pollution with industrial and infectious waste, and the insufficiency of existing water treatment technologies. The study applies theoretical methods such as analysis of scientific literature and synthesis of theoretical material, as well as empirical methods such as laboratory experiments and diagnostic testing using standard microbiology methods. The results indicate that bioremediation is an environmentally safe method for cleaning the aquatic environment, and microbial screening can identify highly effective strains for this purpose.

2. MATERIALS AND METHODS

In the course of the study, the following theoretical methods were used: analysis of scientific and methodological literature of Kazakh and Western European researchers; synthesis and specification of theoretical material over the past 3-5 years; generalisation of research material on microbiology, water purification technologies, ecology, general biology; analogies and modelling. An empirical investigation of the experience of research organisations, normative and educational documentation was conducted during a laboratory experiment, which took place in three stages: ascertaining, forming, and controlling. The methods of mathematical statistics using the programmes Statistica 6.0 and Microsoft Excel 97, graphical images of the results, and drawings were used.

At the ascertaining stage, the study identified the objects of research, which were bacterial strains isolated from the water bodies of Astana – BolshoyTaldykol (BT) and Ulmes (U) lakes and collection test strains of bacteria taken from the Biobank of Industrial Microorganisms of the Republican Collection of Microorganisms: Escherichia coli ATCC 25922 B–RKM 0447, Staphylococcus aureus ATCC-6538 B-RKM 0470, Salmonella enteriditis B-RKM 0680, Klebsiella pneumoniae B-RKM 0444, Enterococcus faecium, Pseudomonass taiwanensis CB2R-1B-RKM 0726, Pseudomonas aeruginosa G13 B-RKM 0427, Aeromonas punctata 30 B-RKM 0287 [2, 3]. Isolation of bacterial isolates from the studied water samples was conducted by the method of marginal dilutions, followed by seeding on pre-prepared Petri dishes with nutrient agar, dry nutrient agar, Czapek, Sabouraud, and Endo media. The cups were incubated at 30°C and 37°C for 1-3 days. Pure cultures were obtained by re-streaking the plates with the appropriate one for each microorganism species. The morphological features and purity of the isolated isolates were checked by staining with a GramStrains-Kit, Himedia staining kit for microorganisms using a MicrosMC300X laboratory microscope (Austria) with immersion oil and ×100 magnification. Cultural signs were considered by standard methods.

At the formative stage, the study determined proteolytic, lipolytic, and amylolytic activities, and carbohydrate fermentation (CF) was conducted according to standard methods used in microbiology. Determination of the phosphate-mobilising activity (PMA) of bacteria was detected on Muromtsev's medium by the Gerretson precipitation method. Antibiotic sensitivity was determined by the standard disco-diffusion method using available antibiotics. Antagonistic activity (AnA) was determined by the method of diffusion in agar along the width of the zone of no growth of available opportunistic cultures. The isolated bacterial pure cultures were identified by mass spectrometry on a MALDI-TOF analyser (Bruker). At the control stage of the experiment, the study drew conclusions and proposed recommendations for the introduction of new virus strains for the bio-purification of polluted reservoirs of Northern Kazakhstan. Statistical processing of the results was conducted using the software package Statistica 6.0, Microsoft Excel 97. In total, 14 isolates of various bacteria were isolated: 8 isolates from Bolshoy Taldykol lake, 6 isolates of bacteria from Ulmes lake, represented mainly by gram-negative bacteria, except for isolate U3.

3. RESULTS

Today, the environmentally safe method of cleaning the aquatic environment is bioremediation – biological stimulation of natural or laboratory-accumulated microorganisms by applying fertilisers to the polluted natural environment [5]. The widest world of microbial diversity provides an opportunity to identify the biochemical potential of microorganisms for obtaining biotechnologically valuable products. Screening of microorganisms is aimed at selecting highly effective strains, in connection with which, the study examined various types of biologically active isolated isolates. The antagonistic properties of bacteria are one of the mechanisms for the formation and functioning of microbiocenosis (Figure 1 and Table 1).

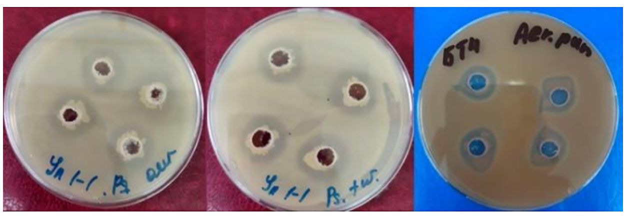

Figure 1. Antagonistic activity of isolates

Table 1. Antagonistic activity of isolates

Name of the isolate	Test strains (mm)							
	E. coli	*St.aur.*	*Salm.ent.*	*Kl.pneum*	*Ent.faec.*	*Ps.taiw.*	*Ps.aer.*	*Aer.pun.*
BT 1	-	-	-	-	-	12.5± 1.50	-	-
BT 2	-	-	16.0± 1.00		18.5± 0.50	16.5±0.50	-	-
BT 3	-	-	-	-	-	-	-	-
BT 4	-	11.0± 0.00	-	-	-	-	-	15.5± 0.29
BT 5/1	-	-	-	-	-	-	-	-
BT 5/2	-	-	-	-	-	-	-	13.3± 0.35
BT 6	-	-	-	-	-	-	-	-
BT 7	-	-	-	-	-	-	-	10.0± 1.00
U 1-1	12.5+ 0.91	15.3± 0.95	-	-	12.0± 1.00	20.0± 0.00	20.0± 0.00	15.5±0.87
U 1-2 zh	12.5± 0.65	16.3± 1.65	-	-	-	-	-	12.3± 1.11
U 1-2 b	-	-	-	-	-	-	-	-
U 2	-	-	-	-	-	-	-	-
U 3	-	-	-	-	-	-	-	-
U 4	-	-	-	-	-	-		-

Note: 9.0 mm or more – high; 5.0-8.9 mm – medium; 1.1-4.9 mm – low; up to 1.0 mm – no antagonistic activity; U – Ulmes lake; BT – Bolshoy Taldykol lake.

It was found that only 7 isolates (U 1-1; U 1-2zh; BT 1; BT 2; BT 4; BT 5/2; BT 7) exhibit antagonistic activity, which is 50% of the total number of isolates. For test strain *Kl. pneumonia*, all isolated isolates showed no inhibitory effect. For the strain *Salm. ent*, only BT 2 isolate showed antimicrobial properties, for the strain *Ps. aer*., the isolate U 1-1 has antagonistic properties. Isolate U 1-1 has the most pronounced antimicrobial properties of all the isolates.

Screening for phosphate-mobilising activity was examined on the ability to dissolve phosphates (Figure 2). During this screening, it was established that 11 isolates (78.5%) have the ability to phosphatemobilise. The zones of dissolution of calcium phosphate ranged from 12.5±0.50 mm to 22.0±0 mm.

Thus, according to the screening, the following 5 isolates are the most active: BT 2, BT 4, U 1-1, U 3, and U 1-2 zh (Table 2). Each new strain of the microorganism obtained in the laboratory was characterised by its properties to collect complete data on microorganisms in pure culture. For this purpose, the identification of isolates was conducted to establish the taxonomic position using the Bruker MALDI-TOF Biotyper system (Table 3).

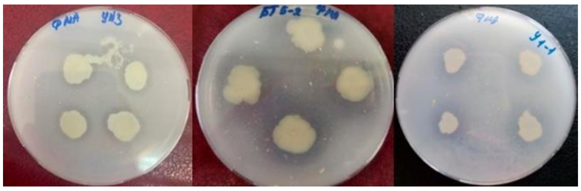

Figure 2. Sensitivity to antibiotics

Table 2. Biological activity of the most active isolates

Isolates	AnA	PMA	PA	LA	AmA	NA	CF	SA
BT 2	++	++	+++	-	-	++++	+	I
BT 4	+	+++	++++	+++	-	++++	+++	I
U1-1	+++	++	+		-	++++	++++	S
U1-2zh	++	+++	++	++	++	++	++++	I
U 3	-	+++	+	-	++	++++	+	I

Note: AnA – antagonistic activity; PMA – phosphate-mobilising activity; PA – proteolytic activity; LA – lipolytic activity; AmA – amylolytic activity; NA – nitrifying activity; CF – carbohydrate fermentation; SA – sensitivity to antibiotics (S – high sensitivity, I – medium sensitivity); ++++ very high activity; +++ high activity; ++ medium activity; + weak activity; - negative result

Table 3. Results of identification of isolates using MALDI Biotyper mass spectrometric analysis

No.	Name	Identification results	The value of points	NCBIidentifier	Gram staining
1	BT 1	*Bacillussubtilis*	2.2	1423	gram +
2	BT 2	*Arthrobacternicotinovorans*	1.976	29320	gram +
3	BT 3	*Rhodococcuserythropolic*	2.12	1833	gram +
4	BT 4	*Serratiamarcescens*	2.277	615	gram -
5	BT 5/1	*Arthrobacternicotinovorans*	2.35	29320	gram +
6	BT 5/2	*Pseudomonasfluorescens*	2.09	294	gram -
7	BT 6	*Serratiamarcescens*	2.3	615	gram -
8	BT 7	*Enterobacter cloacae*	2.32	550	gram -
9	U 1-1	*Bacillus mojavensis*	1.904	72360	gram -
10	U 1-2b	*Arthrobacterhistidinolonovorans*	2.32	43664	gram -
11	U1-2 zh	*Chryseobacteriumgleum*	2.141	250	gram -
12	U 2	*Pseudomonasfluorescens*	2.09	294	gram -
13	U 3	*Arthrobacterhistidinolonovorans*	2.376	43664	gram +
14	U 4	*Shewanellabaltica*	2.14	62322	gram -

Note: NCBI – National Center for Biotechnology Information

As a result of mass spectrometric analysis, bacterial isolates were identified with a high degree of reliability (A score close to 2 or higher). The following generic affiliation was revealed: Bacillus – 2 isolates, Arthrobacter – 4 isolates, Rhodococcus

– 1 isolate, Serratia – 2 isolates, Pseudomonas – 2 isolates, Enterobacter – 1 isolate, Chryseobacterium – 1 isolate, and Shewanella– 1 isolate. The pathogenicity test showed that the newly isolated bacterial strains from natural reservoirs belong to the 3rd and 4th hazard classes. The most active strains were deposited in the Biobank of Industrial Microorganisms of the Republican Collection of Microorganisms.

4. DISCUSSION

The main source of life on Earth is water, it is of particular importance both economically and socially. Water as a source of life forms the climate on the planet, thus affecting all living beings and ensuring a continuous cycle of nutrients. This interrelation of the components of the biosphere makes them dependent on the ecological state of each other and biogeocenoses, in particular [11]. The ecological state of the hydrosphere was understudied, its state is dynamically developing with the advent of technological progress. Unfortunately, modern requirements for water resources management at industrial enterprises are ignored, environmental protection recedes into the background but should be paramount: research in the field of global changes in the biosphere and the climate of the planet. The method of bio-purification of water resources is based on the ability of heterotrophic and autotrophic microorganisms to use a variety of organic compounds as food sources, subjecting the latter to biochemical transformations. Microorganisms are a good indicator for monitoring the ecological state of aquatic ecosystems [12]. Due to their large number, they are easy to obtain in the laboratory for a test sample. The presence of certain microorganisms positively correlates with certain types of pollution. Being a kind of pollution indicator, some microorganisms, when exposed to pollutants, release stress proteins, such as cadmium and benzene. Bacteria with bioluminescent properties are used to detect toxins in the water. The cellular metabolism of the bacterium is immobilised by identifying toxins, which affects the amount of light emitted by the bacteria [13, 14]. To isolate various groups of microorganisms, the study used water samples taken from the following surface sources of Astana:

1. Ulmes is a natural lake recreated as a result of the reclamation of the Taldykol sewage evaporator. The maximum depth is 3.0 m. The category of the lake being reconstructed is a water object of cultural and community water use.

2. Bolshoy Taldykol is a natural lake recreated as a result of the reclamation of the Taldykol wastewater storage evaporator, located in the southwestern part of the city of Astana. The water area of the lake is 292 hectares, the maximum depth is 2.6 m. The category of the lake being reconstructed is a water object of cultural and community water use (Figures 3 and 4).

Figure 3. Bolshoy Taldykol lake

Figure 4. Ulmes lake

Characterisation of bacteria by cultural, morphological, and biochemical characteristics is one of the key conventional taxonomic methods. These features are quite species-specific; their examination is used to determine the species affiliation of the culture under study. The cultural-morphological and physiological-biochemical properties of isolates and collection strains were studied (Table 4).

Table 4. Cultural and morphological and physiological and biochemical features of isolated isolates and collection strains

No.	Name	Cultural and morphological properties	Physiological and biochemical properties
1	U 1-1	Colonies are round, indistinct, have uneven edges, beige, solid, not convex, not transparent, d colonies 3-4 mm, gram-positive rods.	Ferments arabinose, cellulose, glucose, fructose, lactose, maltose; hydrolyses casein.
2	U 1-2zh	Colonies are small, round, yellow, have smooth edges, soft, non-convex, not transparent, d colonies 0.5-1.5 mm, gram-negative bacteria.	Ferments arabinose, cellulose, glucose, galactose, fructose, lactose, maltose, mannitol, xylose, mannose; decomposes (hydrolyses) casein; resistant to penicillin, kanamycin, ampicillin, carbenicillin, neomycin, erythromycin, cefazolin, amoxicillin/clavulanic acid, oxacillin.
3	U 1-2 b	Colonies are small round, have smooth edges, beige, soft, non-convex, not transparent, d colonies 0.5-1.0 mm, gram-positive rods.	Ferments arabinose, cellulose, glucose, galactose, fructose, lactose, maltose, rhamnose, xylose, mannose; decomposes (hydrolyses) casein; resistant to oxacilin.
4	U 2	Colonies are round, beige, have smooth edges, soft consistency, non-convex, opaque, d colonies 0.5-2.0 mm, gram-negative bacteria.	Ferments fructose; resistant to penicillin, ampicillin, vancomycin, carbenicillin, erythromycin, cefazolin, amoxicillin/clavulanic acid, oxacillin.
5	U 3	Colonies are small, round, beige, have smooth edges, soft, not convex, not transparent, d colonies are 0.5-2.0 mm, gram-positive rods.	Decomposes (hydrolyses) casein; resistant to ciprofloxacin amoxicillin/clavulanic acid, oxacillin.
6	U 4	Colonies are round, beige, have smooth edges, soft, slightly convex, not transparent, d colonies are 1.0-3.0 mm, gram-negative bacteria.	Ferments sugars glucose, fructose; resistant to penicillin, amoxicillin /clavulanic acid, oxacillin.

7	BT 1	Colonies are round, blurry, beige, the edges are not smooth, firm consistency, not convex, not shiny, d colonies 1.0-4.0 mm, gram-negative bacteria.	Ferments cellobiose, fructose, maltose, mannose; decomposes casein resistant to penicillin, tetracycline, erythromycin, cefazolin, oxacillin, fusidin.
8	BT 2	Colonies are small, round, beige, have smooth edges, soft consistency, convex, shiny, not transparent, d colonies 0.5-1.5 mm.Gram-positive bacteria.	Ferments cellobiose; decomposes casein; resistant to penicillin, cefazolin, oxacillin, fusidin.
9	BT 3	Colonies are small, light beige, the edges are smooth, soft consistency, not convex, not transparent, shiny, d colonies 0.5-1.0 mm, gram-positive rods.	Ferments mannose; resistant to penicillin, tetracycline, cefazolin, oxacillin, fusidin.
10	BT 4	Colonies are round, translucent, beige, have smooth edges, soft consistency, convex, shiny, d colonies 1.0-2.0 mm, gram-negative bacteria.	Ferments arabinose, fructose, mannose, mannitol, xylose; decomposes casein; resistant to penicillin, tetracycline, cefazolin, oxacillin, fusidin.
11	BT 5/1	Colonies are small, round, beige, have smooth edges, soft consistency, convex, shiny, d colony 1.0-2.0 mm, gram-negative bacteria.	Ferments arabinose, fructose; decomposes casein; resistant to penicillin, tetracycline, erythromycin, cefazolin, oxacillin, fusidin.
12	BT 5/2	Colonies are round, beige, have smooth edges, slightly transparent, soft consistency, convex, shiny, d colonies 0.5-2.0 mm, gram-negative bacteria.	Ferments maltose, xylose, rhamnose; decomposes casein; resistant to erythromycin, carbenicillin, cefazolin, oxacillin, fusidin.
13	BT 6	Colonies are round, small, red, have smooth edges, soft consistency, convex, d colonies 1.5-4.0 mm, gram-negative bacteria.	Ferments maltose, mannose, xylose, rhamnose; resistant to penicillin, oxacillin, fusidin.
14	BT 7	Colonies are round, beige, have smooth edges, soft consistency, convex, shiny, d colonies 0.5-3.0 mm, gram-negative bacteria.	Ferments glucose, fructose, mannose, mannitol; resistant to penicillin, ampicillin, carbenicillin, erythromycin, cefazolin, oxacillin, fusidin.

Burova [15], upon investigating the effect of temperature and pH on the state of rhizosphere microorganisms, established that bacteria from the genus Pseudomonas are characterised by rapid growth. In particular, Pseudomonas chlororaphissub sp. aureofaciens are characterised by rapid growth and the ability to settle in the plant ecosystem and thereby negatively affect micro-organisms that hinder plant growth. Bacteria of this genus are widely used for bio-purification of reservoirs, as they are capable of producing growth hormone and compounds with fungicidal or fungistatic properties, assimilating nitrogen from the atmosphere and phosphorus compounds against phytopathogenic fungi. Important in the isolation of new strains of microorganisms of this kind is the presence of certain factors for their development: the degree of aeration, the acidity of the medium, temperature. However, current research focuses on the use of bioremediation to clean water bodies of pollutants, taking into account these beneficial results.

Snegirev and Karepina [16] examined the photo-disinfecting effect of sensitisers of Escherichia coli culture strains depending on organic water pollution. The museum stick strain (Escherichia coli) is a classic indicator among microorganisms in obtaining sanitary indicators of water. Microorganisms were sown on differential nutrient media by direct seeding and membrane filtration in accordance with the species. In this experiment, Snegirev and Karepina [16] found that the highest efficiency of inactivation of E. coli photodisinfection at a concentration of 0.5 mg/l operates with organic contamination of water with proflavine acetate and methylene blue sensitisers during transillumination for 30 minutes. The authors suggest that these findings demonstrate the potential of sensitisers for the bio-purification of water contaminated with organic pollutants. Annual water consumption on the planet is from 3300-3500 km^3, the demand for this most valuable natural resource is increasing [17, 18]. The authors of the current study recognize the importance of addressing issues related to water pollution and highlight the potential of biotechnologies, such as the use of microorganisms, to help solve these issues. Therefore, biotechnologies use the properties of adaptation of microorganisms to successfully solve the issues of bio-treatment of industrial wastewater, which includes complex organic compounds [19, 20]. The authors of the current study note that the use of microorganisms in biotechnologies is a promising approach for the treatment of industrial wastewater, but caution that careful monitoring is needed to prevent the development of antibiotic resistance. The ability of microbes to quickly acquire resistance to antibiotics requires monitoring their use and finding new means to combat their reproduction [21]. Thus, substances of natural origin are able to regulate the ratios of groups of microorganisms in microbiocenosis. The detrimental effect of organic suspensions on the process of self-purification of waters lies in the sediments with which they cover the bottom and delay or completely stop the vital activity of microorganisms. As they are able to selectively act on various wastewater containing suspensions of organic origin and thus regulate the dissolved organic matter, they negatively affect the state of water bodies [22-24]. Such a mechanism makes it difficult for light to penetrate to depth and hinders the processes of photosynthesis. The authors of the current study acknowledge the importance of photosynthesis in the maintenance of healthy water bodies and suggest that their findings on the use of sensitisers for the bio-purification of water could contribute to the development of sustainable solutions to address water pollution.

Thu et al. [25] investigated the ability of microorganisms to immobilise for the bio-treatment of wastewater with a high concentration of waste from the petrochemical industry. Bio-purification using new strains of microorganisms is ineffective in oil refining production. It is necessary to pre-clean from the active effects of oil refining products, namely, the use of highly active specialised microbial complexes and devices before the wastewater is transported to the general plant treatment facilities. For this purpose, the technology of immobilisation of microorganisms on a polymer carrier was used, which maintains a high concentration of destructor microorganisms and increased the resistance of the biocenosis to adverse factors in the purification system [26, 27]. Thu et al. [25] used a cumulative culture of microorganisms adapted to high concentrations of wastewater components. In the first period (about 20 months), the effectiveness of wastewater pretreatment without using a carrier with fixed microflora was examined. In the second period, lasting from 37 to 46 months, various immobilising carriers in the form of fibreglass ruffs, polyurethane foam, and activated carbon were used. As a result, the breeding community of microorganisms, which are distinguished by a high degree of neutralisation and decomposition of organic sewage pollution, are attached to the fibreglass ruff in the bioreactor. The findings of Thu et al. [25] regarding the use of immobilising carriers to maintain a high concentration of destructor microorganisms and increase the efficiency of bio-purification are relevant to this study.

In turn, Rehman et al. [1] substantiated the method of modifying polyfunctional sorption materials based on the residual biomass of Chlorella sorokiniana microalgae in relation to oil products and heavy metal ions. It was established that the sorption material successfully binds water pollution with oil and petroleum products using composite magnetosorbents, which are easily removed from the water surface using a magnetic field. The development of new technologies to protect the environment from waste pollution from various industrial productions and the cleaning of already polluted areas is an important area of biotechnological research. The efforts of most researchers from different countries are aimed at solving this problem. Therefore, the creation of biotechnologies aimed at detoxification and disposal of pollution of water bodies involves the study of the microbiological status of this anthropogenic ecosystem. Among them, biological methods of pollution purification occupy an important place – the creation of consortia of strains of destructive microorganisms, including immobilised ones [28, 29]. Currently, bacterial cocktails are offered in a wide range by biotech companies in Europe, the USA, Japan, and are in great demand. However, the practice of using foreign bacterial preparations is ineffective due to different climatic and environmental conditions. The potential of biological species is to bring changes to the ecology of the environment [30]. Therefore, the settlement of microorganisms unusual for this water area is one of the biggest threats in the world.

Thus, to prove the effectiveness of microorganisms in wastewater treatment, the article presents the results of screening and characteristics of 14 isolated strains of bacteria, among which 8 strains have high reliability and showed the greatest activity in biological wastewater treatment. Such criteria as antagonistic, phosphate-mobilizing, proteolytic, lipolytic, amylolytic, nitrifying activity, carbohydrate fermentation and sensitivity to antibiotics were used for screening.

5. CONCLUSIONS

Upon analysing the data on the state of water bodies, the study found that pollution occurs due to the absence or inefficient operation of sewage treatment plants. As a result of man-made pollution of surface waters in biological cycles, pollutants are transformed, accumulated, and redistributed to other components of the ecosystem. To minimise the negative impact of pollutants on the hydrosphere, there is an extensive set of methods for water purification from inorganic and organic pollutants, the most effective of which is biological purification – the introduction of new strains of microorganisms into the reservoirs of Northern Kazakhstan.

Thus, the study identified 14 isolates, of which 8 have a high degree of reliability, the following bacterial strains belong to them: Bacillus, Arthrobacter, Rhodococcus, Serratia, Pseudomonas, Enterobacter, Chryseobacterium, and Shewanella. The same isolates were screened for antagonistic, phosphate-mobilising, proteolytic, lipolytic, amylolytic, nitrifying activities, carbohydrate fermentation, and sensitivity to antibiotics. The most active strains were: Arthrobacter nicotinovorans, Serratia marcescens, Bacillus mojavensis, Arthrobacter histidinolonovorans. The strain Bacillus mojavensis was found to be highly sensitive to antibiotics. In addition, in this study, data on microorganisms isolated from wastewater are presented and their destructive activity is verified. The pathogenicity of the isolated bacterial organisms belongs to the 3rd and 4th quality classes. The cultural and morphological and physiological and biochemical features of isolates and collection strains in the reservoirs under study: Bolshoy Taldykol lake, Ulmes lake.

As a result of the introduction of new strains, the technological parameters of the process of enriching the surface of reservoirs were determined, in which 7 isolates exhibit antagonistic activity (U 1-1; U 1-2zh; BT 1; BT 2; BT 4; BT 5/2; BT 7), this is 50% of the total number of isolates. The isolated isolates do not inhibit the growth of the Klebsiella pneumonia test strain. Only one BT 2 isolate (Arthrobacter nicotinovorans) showed antimicrobial properties against the Salmonella enteriditis strain. The most pronounced antimicrobial properties are found in U 1-1 isolate (Bacillus mojavensis), in particular against the Pseudomonas aeruginosa strain. 78.5% of isolates have phosphatomobilising activity. The proposed technologies minimise the anthropogenic impact of industrial enterprises on the environment.

As a result of the research, the authors propose the introduction of new strains of microorganisms for biological purification of polluted reservoirs in the Northern region of Kazakhstan. They have identified 14 isolates of microorganisms that have a high degree of reliability, including Bacillus, Arthrobacter, Rhodococcus, Serratia, Pseudomonas, Enterobacter, Chryseobacterium, and Shewanella. As this study focused solely on the Northern region of Kazakhstan, the generalizability of the findings to other regions or environmental conditions may be limited, and further research is necessary to explore the effectiveness of these new strains of microorganisms in different settings.

The significance of the research lies in the fact that it addresses the important issue of pollution in reservoirs in Northern Kazakhstan and proposes a solution through the introduction of new strains of microorganisms for biological purification. The study contributes to the development of effective strategies for minimizing the negative impact of pollutants on the hydrosphere and improving the quality of water resources in Northern Kazakhstan. The authors propose that future research should explore the use of the new microorganism strains in large-scale bioremediation projects and the development of more efficient production and application technologies.

ACKNOWLEDGMENT

The work was carried out within the framework of the targeted financing program OR11465530 “Creation and replenishment of the collection of industrially valuable microorganisms, the study and preservation of their biological diversity for the needs of biotechnology, medicine and agriculture”.

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