UDC 579.66

Yumchmaa B.

Department of Chemical and Biological Engineering
School of Applied Sciences and Engineering

Hishigshinen D.
Doctoral student

Department of Chemical and Biological Engineering
School of Applied Sciences and Engineering

Chinzorig R.
Assc. Professor

Department of Chemical and Biological Engineering

Erdenechimeg D.
Professor

Department of Chemical and Biological Engineering, School of Applied Sciences and Engineering

National University of Mongolia
Ulaanbaatar, Mongolia

RESEARCH ON ELECTRICAL ENERGY PRODUCTION WITH THE HELP OF MICROORGANISMS USING BIO-ELECTROCHEMICAL SYSTEM

In this study, the microorganisms used to obtain the bioelement were studied; they were isolated at the central wastewater treatment plant in Ulaanbaatar, i.e. samples of industrial waste water IWW), domestic waste water (DW) and sludge (S).

We obtained 79 bacteria from wastewater and 4 bacteria were selected by measuring their oxidation potential with a μStat-I 400 device (bipotentiostat/galvanostat). The bioMérieux VITEK® 2 GN identification card was used to determine the taxonomy and morphological characteristics of the isolated bacteria.

It was confirmed that the DW1 strain is 98 % closely related to E. coli, that the IWW1 strain is 99 % closely related to Morganella morganii, and the DW29 strain is 93 % closely related to Serratia liquefaciens, respectively.

Key words: *microorganisms, bioelement, bacteria, electrical energy production, bio-electrochemical system.*

I. INTRODUCTION

In recent years, due to the rapid development of population density, construction and industry, water pollution has become a global problem. Along with the rapid development of urbanization and industrialization, the amount of water used for domestic and industrial purposes has increased, and the reduction of fresh water has attracted much attention.

There are various chemical, physical and biological technologies for removing pollutants from wastewater. Therefore, there is a great need to study modern methods of suitable, inexpensive and easy to apply wastewater treatment methods. Bioelectrochemical systems, which have advantages over other wastewater treatment methods, are widely used in medicine, agriculture and industry. Recently, bioelectrochemical methods of wastewater treatment have become popular. Before treating wastewater with bacteria, it is very important to determine the composition of water, determine the concentration of elements, the number of bacterial cells per unit volume, as well as determine mineral substances, and establish optimal pH and temperature values. Bioelectrochemical wastewater treatment uses exoelectrogenic strains for power generation and wastewater treatment. These bacteria are able to oxidize organic matter and transfer electrons through their body to the cathode.

In this research, we are working to test the combined efficient technology of using microorganisms in a microbial fuel cell (MFC) device to generate bioelectricity, treat industrial wastewater, and generate electricity.

II. METHODOLOGY

Central treatment facilities were put into operation in 1964. They receive and purify 160-190 thousand cubic meters of household and industrial wastewater per day. As samples for bacterial culture, three types of samples were taken from the central treatment plant: household waste, industrial waste and sludge and used them for the researcher.

Five types of solid media were used for culturing bacteria (nutrient agar, triple sugar iron agar, MacConkey agar, mannitol salt agar, Endo agar).

In the thermostat was incubated at 37^0C for 12 hours in a solid medium. Also incubated for 3 days in a shaker-incubator at 37^0C with a shaking speed of 110 rpm in a liquid medium, took 10 ml of culture, settled and immediately transferred the liquid medium again 3 times, and then inoculated a pure culture on a solid medium(Fig 1).

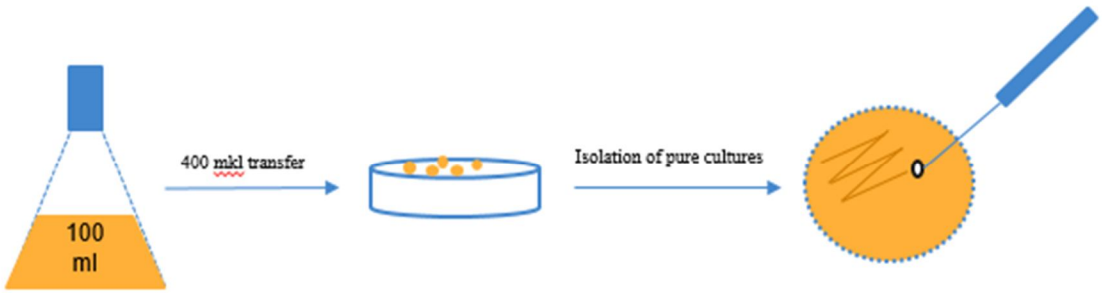


Figure 1: Steps to obtain a pure culture

III. RESULTS AND DISCUSSION

As can be seen from Table 1, the test sample exceeds the allowable limits of the Mongolian standard /MNS 4943:2015/ and the general technical requirements for purified water for reuse /MNS 6734:2018/. For parameters exceeding the standard, BOD 20 mg/l and PPE 50 m/l are considered acceptable. Since the chemical and biological contamination is 14 times greater, it was considered water suitable for use in our bioelectrochemical devices(Table 1).

Table 1

Comparison between Mongolian standard MNS 4943:2015 and the analysis results of samples taken in the study

№	Indicator	Norm	Acceptable amount	Entrance	
			Environment. Water quality. Waste water. General requirements MNS 4943:2015	Household Waste water	Industrial waste water
1.	pH	1-14	6-9	7.93	8.26
2.	Smell	do not feel	Not detectable	2	2
3.	BOD	мгО/л	20	702	322
4.	COD	мгО/л	50	242	127
5.	Mineralization	мг/л	1000	1187	1229
6.	H_2S	мг/л	0.5	119	59.5
7.	Total iron Fe^{2+3}	мг/л	1	1.05	1.08
8.	Fat	мг/л	5	12.3	<0.5

Wastewater and sludge bacteria were cultured in 150 Petri dishes by preparing five nutrient media: nutrient agar, TSI agar, MacConkey agar, mannitol agar, and Endo agar (Figure 2).

To create a favorable environment for the growth of bacteria, it was cultivated on a liquid nutrient medium for 3 days, 10 ml were taken and transferred to a liquid nutrient medium, cultivated 3 times with a change in the medium.

Figure 2. Cultivation of bacteria in nutrient medium

After isolating the pure culture, morphological features were determined. 79 pure cultures with various morphological characteristics were selected.

Also, 4 bacteria with high oxidative activity were selected from 79 pure cultures (shown in Fig. 3)

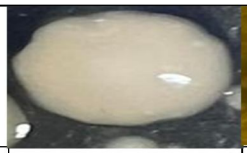
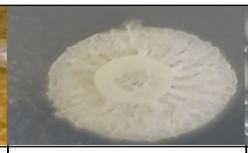
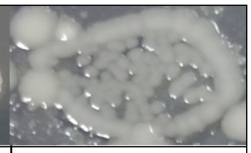
Pictures of bacteria				
The name of the sample	Household waste #1	Household waste #29	Industrial waste #1	Clay #8
The name of the medium	MacConkey Agar	Nutrient agar	MacConkey Agar	Nutrient agar
Morphological features				
Size	2 mm	2*2mm	1.5 mm	0.7*0.6 mm
Color	Yellow	Yellow	White light	White light
Surface	Budger	Flawless	Rough	Point
Товойлт	Embossed	Flat	With a head	Flat
Bump	Full	Full	Full	Full
Form	Wheel	Uneven	Wheel	Point
Structure	Stuck	Moisture	Moisture	Stuck
Light absorption	Transparent	Translucent	Translucent	Translucent

Figure 3. Morphological characteristics of 4 selected bacteria

CONCLUSION

1. The amount of biologically and chemically necessary oxygen contained in industrial and domestic wastewater entering the central treatment plant exceeds the standard value by 6 and 14 times, respectively, which indicates a high degree of wastewater pollution.

2. «Nutritional broth» turned out to be the most selective for the cultivation of bacteria on 5 types of wastewater media, so 79 types of pure bacterial cultures with different morphological features were isolated from wastewater samples, including cultures AN-1, AN-29, XX-1 and L-8 were shown by cyclic voltammetry to be exoelectrogenic bacteria with high oxidation rates (1985-2278 μA).EX, $\Delta G = -24 \times 96500 \times 1.759 = -4074$ K, we believe that the reaction ($\Delta G<O$) can be conducted spontaneously by using microorganisms to extract electrical energy.

LIST OF REFERENCES

1. Mongolia Millennium Challenge Fund Public Relations Team // World Water News. – Ulaanbaatar. – 2021. – January.

2. Asimina Tremouli, Michalis Martinos. The Effects of Salinity, PH and Temperature on the Performance of a Microbial Fuel Cell. – 10.2022.

3. Chinedu D., Ahuchaogu and Kausik S., Harvesting Electrical Energy Produced by Electrogenic Bacteria in Microbial Fuel Cells. – 2020.

4. Galt L. Microbiology. – Ulaanbaatar, 2009.

5. Charles Amanze, Xiaoya Zheng, Zhaojing Yu, Erdenechimeg Dolgor, Weimin Zeng, Recovery of heavy metals from industrial wastewater using bioelectrochemical system inoculated with novel Castellaniella species / Central South University changsha, China.

6. Modestra J.A., Navaneeth B., Venkata Mohan S. Bioelectrocatalytic reduction of CO2: enrichment of homoacetogens and pH optimization towards enhancement of carboxylic acids biosynthesis // CO2 Utilization. – 2015. – № 10. – P. 78–87.

7. Nancharaiah Y.V., Lens P.N.L. Ecology and biotechnology of selenium- respiring bacteria // Microbiol. Mol. Biol. Rev. – 2015a. – № 79. – P. 61–80.

8. Nancharaiah Y.V., Lens P.N.L. Selenium biomineralization for biotechnological applications // Trends Biotechnol. – 2015b. – № 33. – P. 323–330.

9. Nancharaiah Y.V., Joshi H.M., Mohan T.V.K., Venugopalan V.P., Narasimhan S.V. Aerobic granular biomass: a novel biomaterial for efficient uranium removal // Curr. Sci. – 2006. – № 91. – P. 503–50.

Юмчаа Б.

Кафедра химической и биологической инженерии
Школа прикладных наук и инженерии

Хишигшинен Д.
докторант

Кафедра химической и биологической инженерии
Школа прикладных наук и инженерии

Чинзориг Р.
доцент

Кафедра химической и биологической инженерии

Эрденечимег Д.
профессор

Факультет химической и биологической инженерии, Школа прикладных наук и инженерии

Национальный университет Монголии
г. Улан-Батор, Монголия

ИССЛЕДОВАНИЕ ПРОИЗВОДСТВА ЭЛЕКТРИЧЕСКОЙ ЭНЕРГИИ С ПОМОЩЬЮ МИКРООРГАНИЗМОВ С ИСПОЛЬЗОВАНИЕМ БИОЭЛЕКТРОХИМИЧЕСКОЙ СИСТЕМЫ

В представленном исследовании были изучены микроорганизмы, используемые для получения биоэлемента; они были выделены на центральной станции очистки сточных вод в Улан-Баторе, т.е. из образцов промышленных сточных вод (IWW), бытовых сточных вод (DW) и ила (S).

Мы получили 79 бактерий из сточных вод, и 4 бактерии были отобраны путем измерения их окислительного потенциала с помощью прибора μStat-I 400 (бипотенциостат/гальваностат). Карты для идентификации клинически значимых грамотрицательных палочек VITEK® 2 GN были использованы для определения таксономии и морфологических характеристик выделенных бактерий.

Было подтверждено, что штамм DW1 на 98 % тесно связан с E. coli, что штамм IWW1 на 99 % тесно связан с Morganella morganii, а штамм DW29 на 93 % тесно связан с Serratia liquifaciens, соответственно.

Ключевые слова: *микроорганизмы, биоэлементы, бактерии, производство электроэнергии, биоэлектрохимическая система.*