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Research

EXPERIENCE IN APPLICATION OF OZONIC TECHNOLOGY FOR SEWAGE TREATMENT IN THE KUMKUL REGION OF KAZAKHSTAN

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ABSTRACT

The article considers the experience in application of ozonic technology for sewage treatment in a certain region, which is the Kumkul region of Kazakhstan. There is a flow chart of the developed ozonation plant with the description of its operation principle. There are also the results of the conducted experiment with the application of this plant for sewage treatment. Finally, we make the conclusion about viability of spreading ozone application for sewage treatment in the other regions of Kazakhstan.

INTRODUCTION

In Kazakhstan significant attention is paid to environment protection from pollutions. Great efforts are put in lowering pollutions of water bodies.

Mineral and organic impurities can enter the water bodies from production plants and inhabited localities, which results in a great number of heavy and light metals occurred in the water as well as organic compounds and toxic substances (Birimzhanov, 1970; Kulkiy and Strokach, 1986).

The most efficient method of improving quality of water is application of ozonic technology.

Ozone has high degree of oxidation of organic and inorganic substances. Application of ozonic technology allows significantly decreasing concentration of metals, organic compounds and toxic substances Drinking Water. Hygienic Requirement. (SanPiN, 2001; Kozhaspaev and Abdykadyrov, 2008).

Ozonized water becomes clearer, there is almost no turbidity, the odor becomes clearer, etc.

Optimum conditions for application of ozonation with further filtration are defined only by means of conducting special scientific researches at a certain plant.

During recent ten years the Department of Electric Engineering at "Satpayev Kazakh National Technical University", National Joint-Stock Company has been performing the works at application of ozone for the purpose of protection of environment and efficient use of material resources. We have developed a series of technologies based on the conducted experimental studies and scientific data. The scope of works embraces over ten directions in industry and agriculture.

Ozone is used in various branches: chemical, oil, etc. for disinfection of drinking water, treatment of industrial and sewage water. The application of ozone is rapidly expanding in medicine, biotechnology, agriculture, etc.

MATERIALS AND METHODS

The most efficient and energetically viable method of obtaining ozone is currently its generation at corona discharge. Ozonation plants, developed by this principle, can provide the required ozone performance both for industrial and for household purposes. The main disadvantage of the majority of ozonation plants both of national and foreign production is low operating resource. In connection with this, the rise of resource and simplification of

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ozone plants operation is an actual problem. Besides these problems, efficiency and cost of ozonation plants are also important.

With the purpose of lowering sewage pollution of the Kumkul region of Kazakhstan, the Department of Electric Engineering at "Satpayev Kazakh National Technical University", National Joint-Stock Company has developed an experimental plant, using ozonic technology (Draginskiy, *et al.*, 2007) (Fig. 1).

By means of the control unit (4), the plant is put into operation. Slowly increasing the voltage by the laboratory transformer to 120 V, we switch on the compressor (3). The compressor pumps open air into the ozonizer (1). The ozone obtained by the ozonizer is transferred to the steam blower through the pipe (15). The steam blowers located in the feed water tank (8). By means of the control unit the pump (5), which pumps the water out of one tank (7) to another (8) is switched on. In the tank (8) ozone and water are mixed up and oxidizing process occurs. In a while the water treated by means of the control unit is pumped out one tank (9) to another (16). The gauge device (9) checks up the quality of the tank (16) treated water. If the quality of the treated water does not comply with the National Standard, then the control unit switches up the pump (6), which pumps the water from one tank (16) through the pipe (10) to another tank (7). The process of the water treatment is repeated. If the water complies with the standards, then the treated water is supplied to consumer. By means of the pumps (5) and (6) the filters (12) and (13) are activated, which treat the water mechanically. Fig. 2 shows flow chart of the ozonizer.

Air preparation unit

The air preparation unit in general case consists of 2 blocks: the first block is the compressor; the second one is air cleaning from dust, usually consisting of filter. The operation mode is the following: ozonator was working 1.5 h, then was switched off and the dryer was working for 30 min. Then the process repeated. The air preparation unit was used in ozonizers with a productivity rate of over 10 g/h. The ozonizers having lower productivity rate were used without the air preparation unit.

Ozone injection device (ejector or steam blower) (ozone+water)

For disinfection of air environment as this unit an ordinary tube is used, which is made of ozone-resistant material. At water treatment ejector and steam blower were applied. Such well-known devices were computed and manufactured in the laboratories of the university.

Power sources

The majority of the researches were conducted with high voltage power supply at industrial frequency 50

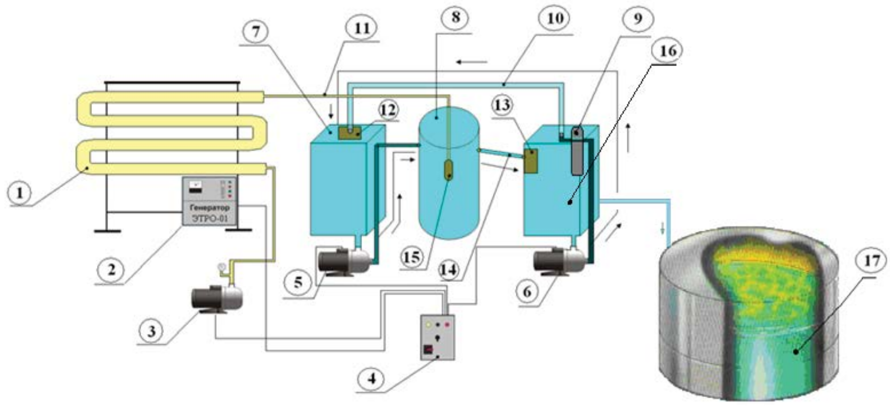

Fig. 1 General View of the Plant: 1 – ozonizer (ozone generator); 2 – high voltage rectifier; 3 – compressor; 4 – plant control unit; 5, 6 – water pumps; 7, 8,16– water tanks; 9– gauge device for water quality control;10, 14 – water piping; 11 – pipe, transferring ozone and air mixture to the treated water tank; 12, 13 – filters; 15 – steam blower; 17 –*treated water.*

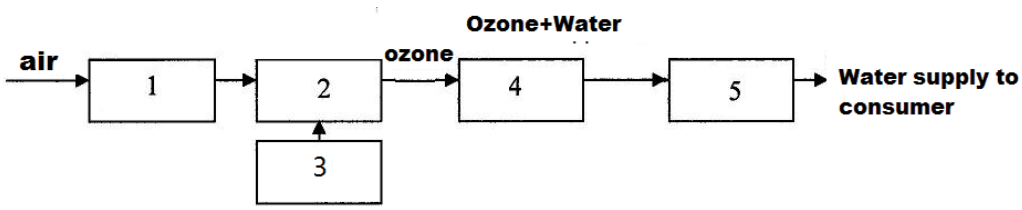

Fig. 2 Ozonizer Flow Chart: 1 – air preparation unit (compressor); 2 – ozonation chamber; 3 – power supply (high voltage rectifier); 4 – contact chamber (Ozone+water); 5 – treated water tank.

Hz. The main element of such simplest sources was high voltage transformer. A series of the experiments were conducted at frequency 7 kHz to 13 kHz from electromechanic power source. Previous ozonation plants were powered by the sources at frequency 50 Hz. After general developments at the ozonation chambers the efforts were focused on the high frequency supply sources. A simple well-known silicon controlled rectifier scheme was taken as a basis, which was supplemented by several elements. It resulted in creation of power supply sources with frequency 1 kHz to 2 kHz, capacity from 100 VA to several kVA. The experiments showed their reliable and stable operation. The sources have come to be very cheap, the number of elements is 10 units. For obtaining high voltage we used transformers NOM-6, NOM-10 or TGMUHL.

Ozonation chambers

This is the basic element of the ozonation plant. Ozonation chamber is the unit where ozone is being synthesized. Traditionally ozonation chamber consists of two electrodes, one or two non-conducting barriers. Between the electrodes (barriers) there is a discharge gap with the length of 5 mm to 10 mm. Ozonation chambers are made cylindrical or plate. In our case we investigated and manufactured generally cylindrical chambers as the most technological. The most vulnerable elements of the chamber are barriers. Thermal exposure of microdischarges leads to erosion and then voltage failure occurs.

RESULTS AND DISCUSSION

Before ozonation we conducted analysis of the feed water. In the composition of such water we found large quantity of various metals and toxic substances, exceeding maximum permissible concentrations (Kozhaspaev and Abdykadyrov, 2009). The results of the researches are represented in the Table 1 of the change of chemical water composition before and after ozonation. The change in chemical composition of polluted water of the Kumkul deposit.

The data of change in chemical composition of water represented in the Table 1, confirm significant decrease in pollution of such substances as iron, zinc, arsenic, manganese and cobalt. The Table 1 shows that the water was cleared out of metals and toxic substances in average by 70% to 80%.

There are the reactions of some metals oxidation represented below.

Iron (Fe): Formation of low soluble oxidized modifications of iron and manganese influenced by ozone has been known for a long time. The process of oxidation of ferrous iron can be represented by the following scheme:

$$Fe^{+2} + O_3 + H_2O \rightarrow Fe^{+3} + O_2 + 2OH^- \quad (1)$$

$$Fe^{+3} + 3H_2O \rightarrow Fe(OH)_3 \downarrow + 3H^+ \quad (2)$$

In the process of the experiment, when index pH was equal to 6.8 and concentration of ozone per 1 m^3 of water was 120 mg, the concentration of iron in water decreased from 0.15 mg/l to zero. Oxidation of manganese is a more complicated process. When pH is from 5 to 7 there is formation of quadrivalent manganese oxide, low soluble in water:

$$Mn^{2+} + O_3 + H_2O \rightarrow Mn^{+4} + O_2 + 2OH^- \quad (3)$$

$$Mn^{+4} + 4OH^- \rightarrow MnO_2 \downarrow + 2H_2O \quad (4)$$

Simultaneously there is oxidation of initial soluble bivalent manganese to a higher degree of oxidation with formation of permanganate soluble in water:

$$2Mn^{2+} + 5O_3 + 3H_2O \rightarrow 2MnO_4^- + 5O_2 + 6H^+ \quad (5)$$

After oxidation of manganese, cobalt and nickel it is necessary to perform filtration. Concentration of manganese after oxidation decreases from 2.54 mg/l to 1.25 mg/l (Kozhaspaev and Abdykadyrov, 2009; Kozhaspaev, *et al.*, 2009).

At index pH equal to 6.8, zinc, chrome together with OH^- ions form hydroxides. Among these metals chrome oxidizes to hexavalent chromium. (Kozhaspaev, *et al.*, 2009).

$$Zn^{2+} + O_3 + H_2O \rightarrow Zn^{2+} + O_2 + 2OH^- \rightarrow Zn(OH)_2 \downarrow + O_2 \uparrow \quad (6)$$

$$2Cr^{3+} + O_3 + 3H_2O \rightarrow 2Cr^{3+} + 6OH^- \rightarrow 2Cr(OH)_3 \downarrow \quad (7)$$

Table 1. Chemical composition of the analyzed water

Substances	Unit mg/l	Concentration before ozonation	Concentration after ozonation	Treatmentefficiency, %
Iron	mg/l	0.15	-	100
Zinc	mg/l	0.08	-	100
Chrome (VI)	mg/l	0.001	-	100
Chrome(III)	mg/l	0.006	-	100
Cobalt	mg/l	0.012	0.005	58.3
Arsenic	mg/l	16346.75	6811.14	58.4
Manganese	mg/l	2.54	1.25	50.8

$$Cd^{2+} + O_3 + H_2O \rightarrow Cd^{2+} + 2OH^- + O_2 \rightarrow 2Cd(OH)_2\downarrow + O_2\downarrow \quad (8)$$

Cobalt (Co): At pH value equal to 6.8 and in the process of cobalt oxidation its concentration decreases from 0.1012 mg/l to 0.005 mg/l (Kozhaspaev and Abdykadyrov, 2009; "Tospasu" Public Utility Corporation, 2012).

$$Co^{3+} + 3OH^- \rightarrow Co(OH)_3\downarrow \quad (9)$$

$$Co^{2+} + 2OH^- \rightarrow Co(OH)_2\downarrow \quad (10)$$

$$Co(OH)_2 + O_3 + 2H_2O \rightarrow Co(OH)_3\downarrow O_2 + OH^- \quad (11)$$

Arsenic (As): One of the most toxic metals in the composition of water is arsenic. This metal interacts with ozone according to the following reaction:

$$ASO_2^- + 2OH^- + O_3 \rightarrow ASO_4^{3-} + O_2 + H_2O \quad (12)$$

Concentration of arsenic decreases from 16346.75 mg/l to 6811.14 mg/l (Kozhaspaev and Abdykadyrov, 2009; Kozhaspaev, *et al.*, 2009).

Molybdenum (Mo): At pH equal to 6.8, molybdenum preserves its form in water, forming residuum caused by absorption.

$$2Fe(OH)_3\ 3MoO_4^{2-}\ 6H^+ \rightarrow Fe_2(MoO_4)_3\ 6H_2O \quad (13)$$

CONCLUSION

The represented data confirm that at the stage of treatment the concentrations of pollutions significantly decrease, while in the treated filtrated water there is almost no turbidity and colority.

Judging by the results of researches of the Kumkul water it is seen that application of activated carbon and zeolite makes sorption purification more efficient. Total removal of organic impurities increases approximately by 40% to 45%. After ozonation indicator values of iron, zinc, cobalt, arsenic, manganese, metal ions and other impurities significantly decrease (Table 1).

The results of the conducted experimental researches allow concluding that the experience of application of ozonic technology for sewage purification can be spread in the other regions of Kazakhstan.

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