Criteria and methodological approach to assessment of wastewater treatment methods

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Abstract. When assessing water quality, there are several criteria. In the first place is the standardization factor, including limits on the withdrawal of water from sources, limits on the discharge of wastewater and the maximum mass of pollution for each ingredient. Further, water use implies three main types: 1) hygienic requirements for drinking water; 2) the quality of water for cultural purposes; 3) to the waters of fishery purposes. With the transition of Russia to the market, fundamentally changed attitudes towards ecology and raw materials, to technical policy, improving methods and means of wastewater treatment in order to extract useful elements from them and rational waste disposal. However, the problem of priority protection of domestic “know-how”, especially in environmental issues, aggravating the difficult social environment, remained relevant. Thus, there is a need to develop criteria and methods for minimizing costs while maintaining natural sources and wastewater treatment. There is a need to calculate socio-economic efficiency when it comes to the introduction of non-waste technologies related to the environment, which improves the social situation and the country's prestige on a global level. Consider some points linking these problems with the solution of the problems of economics and ecology. It is necessary to highlight such aspects of the problem as: monitoring of harmful components, the cost-effectiveness of water treatment methods and the development of new methods for the production of effective sorbents and reagents. A separate article is the non-waste processes. In industrialized countries, the same problems exist that are often solved by rational disposal methods.

1 Introduction

From the standpoint of the ecology of life safety, scientific and technological progress, with the increasing influence of man on nature, leads to an aggravation and deterioration of the environmental situation in the World [1]. At the same time, natural resources are depleted, the natural sphere is polluted. The economic and political struggle for territory is escalating. As a result, commodity markets are disrupted, and the quality of life is deteriorating. Hence,

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the orientation of the state's environmental policy, legislation, and scientific aspects of environmental law to ensure the environmental safety of the population, to protect natural environments and more prudent use of the country's raw materials is relevant. The other side of the problem is also relevant - material compensation in one form or another of harm caused to nature and human health. Of course, all this should be carried out in conjunction with economic, political, moral-educational and educational measures on the part of the Russian state at the level of legislative foundations [1].

2 Methods

When assessing water quality, there are several criteria. In the first place is the standardization factor, including limits on the withdrawal of water from sources, limits on the discharge of wastewater and the maximum mass of pollution for each ingredient [2]. Further, water use implies three main types: 1) hygienic requirements for drinking water; 2) the quality of water for cultural purposes; 3) to the waters of fishery purposes. With the transition of Russia to the market, fundamentally changed attitudes towards ecology and raw materials, to a technical policy, improving methods and means of wastewater treatment in order to extract useful elements from them and rational waste management. However, the problem of priority protection of domestic "know-how", especially in environmental issues, aggravating the difficult social environment, remained relevant. Thus, there is a need to develop criteria and methods for minimizing costs while preserving natural sources and wastewater treatment. There is a need to calculate socio-economic efficiency when it comes to the implementation of non-waste technologies related to the environment, which improves the social situation and the country's prestige on a global level. Consider some points linking these problems with the solution of the problems of economics and ecology. It is necessary to highlight such aspects of the problem as: monitoring of harmful components, the efficiency of water treatment methods and the development of new methods for the production of effective sorbents and reagents. A separate article is the non-waste processes. In industrialized countries, there are the same problems that are often solved by rational disposal methods. Most often, the experience of these countries is unacceptable to us because of the technical unpreparedness of our enterprises. The specifics of Russia is the instability of the transition period, the lack of opportunities to effectively invest in non-traditional industries. The urgency of the problem is aggravated by the fact that in Russia, like nowhere else in the world, a large amount of unclaimed bulk, fibrous, film, oil waste from textile, light industry, transport, related industries and the construction industry that are used irrationally (burned, dumped), has been accumulated, pollute the aquatic environment in the area of operation of enterprises and around industrial centers In practice, sorbents and various methods of water purification are used for four dispersion groups: I - suspensions with a particle size of more than 10-1 microns, emulsions and suspensions creating turbidity of water, including microorganisms and plankton; II - colloidal solutions with particle sizes of 10-1 - 10-2 microns, high molecular weight compounds that determine the oxidizability and color of water, viruses; III - molecularly dissolved substances with particle sizes of 10-2 - 10-3 microns, gases, organics, which gives odors and taste to water; IV - substances that dissociate into ions with particle sizes less than 10-3 microns, salts, acids, bases. Thus, it is necessary to investigate the whole complex: potential opportunities for developing methods and production of sorbents and wastewater treatment methods, methods for monitoring and evaluating socio-economic efficiency, taking into account minimization of costs for all types of processing.
3 Results and Discussion

One of the aspects of the hypothesis of processing waste into sorbents is the use of the fundamentals of thermodynamic theory in the modification of rheological substances (by mechanical and thermodynamic destruction and regeneration) and in the transformation of phases of raw materials. This can be realized by processing waste into basic components, from which new composites with desired properties can be obtained. It is about creating a new theory of matching phases of dissimilar materials with new properties by simple mechanical combination under normal conditions. Thus, fundamentally new sorbents can be obtained using intermediate phases or ballast materials. It is about creating a new theory of matching phases of dissimilar materials with new properties by simple mechanical combination under normal conditions. Thus, fundamentally new sorbents can be obtained using intermediate phases or ballast materials. There is no information in the literature on the direct use of solidified colloidal substances waste or liquefied solid impurities for the production of binders or sorbents. It is important to note that a necessary condition for the implementation of the concept is the exception, with the aim of creating extremely safe technologies for health, the use of harmful chemical processes and reagents. The use of processing methods based on the principle of mechanical mixing of differently dispersed and different-phase components allows us to significantly change the approach to the design methodology for processing waste products into consumer goods. The physicomechanical approach to wastewater treatment will make it possible to successfully use the fields of molecular physics, thermodynamics, and technology of structural materials and will create the scientific basis for the design of technology.

Cleaning methods are divided into mechanical, chemical, physicochemical, thermal and biological. Perhaps their combined use. The application of methods in each case is determined by the nature of the pollution and the degree of their harmfulness. Effectively applying the method of electrochemical wastewater treatment [3], containing wastewater of metals, acids and alkalis, which allow to extract and use the bulk of valuable products and metals simultaneously with purification.

Electrochemical treatment is a type of physicochemical method when the process of electrochemical wastewater treatment occurs under the influence of electric current. These methods are characterized by multi-stage and relative complexity of physicochemical phenomena occurring in the water treatment apparatus. The mechanism and speed of the individual stages depends on many factors, the identification of the influence and the correct accounting of which are necessary for the optimal design of electrolyzers and the rational management of water treatment processes.

Based on the laws of physical chemistry, electrochemistry and chemical technology, electrochemical methods for treating industrial wastewater can be divided into three main groups: conversion methods, separation methods, and combined methods. The conversion methods provide a change in the physico-chemical and phase-dispersed characteristics of wastewater pollution in order to neutralize them and quickly remove them from wastewater. The conversion of impurities can go through a series of successive stages, starting with the electronic level of interaction of soluble compounds and ending with a change in any electro-surface and volume characteristics of coarse-dispersed substances contained in wastewater.

Separation methods are designed to concentrate impurities in the local volume of the solution without significantly changing the phase-dispersed or physico-chemical properties of substances extracted from wastewater [4-8]. Separation of impurities and water occurs mainly due to flotation by electrically generated gas bubbles or by the force of an electric field that ensures the transport of charged particles in water. Combined methods of electrochemical wastewater treatment include methods that involve combining one or more of the methods of conversion and separation of sewage pollution in one apparatus.
Electroflotation consists in saturating the purified water with microbubbles of hydrogen and oxygen, formed during its electrolysis under the influence of direct electric current. Oxygen oxidizes the petroleum products in the water, forming simpler compounds, and hydrogen bubbles, with great lift, carry particles of petroleum products and coagulated suspended solids to the surface of the water.

Electrocoagulation (galvanocoagulation) - technologically obsolete methods that are still used at engineering and metalworking plants for wastewater treatment of galvanic production (mainly for purification of chromium-containing wastewater from chromium ions Cr$_6^+$(aq)). In these methods, iron is dissolved by the electrochemical mechanism, and the formed Fe$_2^+$ ions reduce hexavalent chromium Cr$_6^+$ to trivalent Cr$_3^+$ followed by the formation of chromium hydroxide. The difference between electrocoagulation and galvanocoagulation lies in the method of dissolving iron.

In the electrocoagulation method, iron dissolves electrochemically when a potential is applied to steel anodes from an external power source. In the galvanic coagulation method, iron is dissolved galvano-chemically due to the potential difference arising from the contact of iron with copper or coke. Therefore, both methods differ in the driving force of the process of dissolution of metallic iron, which determines their technological differences.

The electrolysis of solutions of salts with a soluble anode is reduced to the oxidation of the anode material (its dissolution) and is accompanied by the transfer of metal from the anode to the cathode. This property is widely used in the refining (cleaning) of metals from contaminants [9,10]. If the anode material has a potential more negative than the oxidation potential of hydroxide ions to free oxygen, then the anode dissolves and this type of electrolysis is called electrolysis with a soluble anode. During electrochemical treatment, soluble and insoluble electrodes are used.

As soluble, for example, aluminum, iron and other electrodes are used, the ions of which, entering the solution during electrolysis, have good coagulation properties. At soluble electrodes, metal is ionized with a transition to a solution of its ions

$$Me - ne = Men^+$$

which hydrolyzed form:

$$Men^+ + nH_2O = (OH)_nMe + nH^+,$$

that is, metal hydroxides are good coagulants of contaminants and adsorbents for already coagulated particles. During electrolysis, water decomposes with alkalization of the treated liquid at the cathode and with acidification at the anode:

$$2H_2O + 2e = H_2 + 2OH^– , H_2O - 2e = 1/2 O_2 + 2H^+.$$

When liquid passes between the electrodes under the influence of an electric field, the charge of polluting particles is neutralized, followed by their coagulation. At the same time, gas bubbles formed during electrolysis carry out flotation of contaminants. The processes that occur during electrochemical cleaning in an installation with aluminum electrodes are presented.

As insoluble anodes, materials with large positive reduction potentials (Pt, Au, C) or metals with high values of anode polarization (Ta, Ti, Fe in an alkaline medium, etc.) are used. Insoluble electrodes made of graphite, magnetite - MTA, metal-oxide anode - MOA, glassy carbon anodes, etc. are used in the practice of treating water and water drains. Insoluble electrodes, in addition to the process of electrochemical pollution flotation, at pH
= 8.9, give the process of electrochemical pollution destruction at the cathode and at the anode. Then the wastewater disinfection occurs with hypochlorite ions, which are formed on the anode [3, 10,11]. This occurs when chlorides are present in wastewater or when hydrogen peroxide and ozone appear during electrochemical processes.

4 Conclusions

Effective Russian state environmental policy and actions today cannot do without costly line items, which is obvious. This will give hope for national survival in the context of the global environmental crisis. The allocation of resources in the event of the development of catastrophic events according to a pessimistic scenario is also relevant. Another direction is the implementation of measures to achieve an acceptable level of changes in key environmental programs, which is important not only for Russia but also for other countries. The importance of the task of forming the state environmental policy of Russia implies participation in its development of public organizations, including environmental parties, public movements, and youth. This may turn into one of the necessary conditions for maintaining controllability by the processes of resuscitation of nature. The implementation of the state environmental policy, its most important areas, should probably be carried out in such a way as to ensure the formation of a positive environmental worldview of the population, including spiritual and moral education and youth education.

It is also necessary to master the world environmental standards in cooperation in the system "nature - man - society - nature". It is also necessary to achieve constructive cooperation between society, the state, and citizens in protecting public health and the environment. It is necessary to ensure the introduction of environmentally acceptable technologies, the rational use of the country's natural resources and to develop a system of environmental law and order. It is necessary to turn environmental, economic and social factors into an integral component of managing the country's economic and social development.

It is also necessary to realize the inalienable right of every citizen to a favorable and safe living environment. If we are talking about innovation, then one of the aspects of the new hypothesis of processing waste into sorbents is the use of the fundamentals of thermodynamic theory in the modification of rheological substances (by mechanical and thermodynamic destruction and regeneration) and in the transformation of phases of raw materials. This can be realized by processing waste into basic components, from which new composites with desired properties can be obtained.

As a result, it can be noted that scientific knowledge, technology, human and natural resources are quite enough for Russia to overcome the ecological, technological and economic crisis and realize the mission of a great environmental power. This is especially important from the perspective of the development, considered in this article, of new effective technologies and methods for treating wastewater of communal and industrial enterprises.

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