Implementing a cluster-based method for managing solid waste in the coastal zone of the Black Sea

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Abstract. The analysis of existing problems of intensively developing infrastructure of the coastal zone of the Black Sea in the field of accumulation of wastes is presented and the optimal ways of its solution at the initial stages of designing of the refuse processing enterprises are offered. The purpose of the work to show that the creation of a full cycle of recycling solid waste will significantly improve the economic and environmental performance of the Ministry of Ecology and Nature Conservation of the Republic of Crimea. Calculation of required industrial capacities of the rubbish processing enterprise is made; the approach in the field of the waste treatment, differing from the existing archaic methods of disposal and based on the cluster distribution is offered. Clustering will make it possible to carry out deep processing of raw materials, to reduce to zero the volume of burial of waste, to transport it to the place of final processing by railway and automobile transport, which will considerably simplify logistics. Such measures will significantly reduce the effect of negative impact on the environment, generate useful capacities in the form of heat and electricity for domestic and industrial consumption, and attract additional investments to the region, increasing the revenue part of the budget of the region as a whole. The proposed approach is well aligned with the national Ecology Project.

1 Introduction

The problem of protecting the aquatic environment of the Black Sea from adverse anthropogenic impacts is of a complex nature. In this field there are closely intertwined the issues of parameters, adequately reflecting the state of the aquatic environment and methods of their study, rationing the most dangerous for the ecosystem impacts, engineering methods of regulation of anthropogenic load on marine ecosystems [1-4].

Ideally, one would certainly like to have environmentally friendly industrial plants on the Black Sea coast and along the rivers flowing into it, environmentally sound agriculture, environmentally friendly transport, no uncontrolled potential pollution sources, etc. This
should be aspired to, but something can be attempted without waiting for a major overhaul of industrial and agricultural technology. Protecting the natural environment and managing its quality is only possible if the state of the environment is constantly monitored, changes related to anthropogenic activities are identified and future trends in this state are foreseen. The environmental monitoring system should provide information:

- on the sources of environmental pollution;
- on environmental factors (chemical, physical, biological) that lead to pollution of the environment;
- on the state of biosphere elements (reactions or responses of fauna and flora, atmosphere, hydrosphere, soil to external impacts);
- on the quality of biosphere elements (biotic and abiotic components of the biosphere).

The objects of monitoring are man and his health, populations of fauna and flora, microorganisms, atmospheric air, surface and groundwater, soil, subsoil, near-Earth space, industrial and domestic wastes, effluents, emissions, physical impacts, biogeocenoses and, finally, the biosphere as a whole. Each of the objects corresponds to its own type of monitoring. In order to preserve the ecological balance on the territory of the Russian Federation, the authorities, science and civil society should work out through an open dialogue a new concept and technology in the issues of: reduction of buried waste, increase of recycling volumes, safe utilization of industrial and domestic waste.

It is known that about 94% of waste in Russia remains in special landfills due to an acute shortage of production capacity and a lack of deep processing technology. At the same time, the greatest concern is industrial waste, which has been accumulated for years, decades, and so far its volume is only increasing. The current situation in the Republic of Crimea may create additional problems for the leadership of the region and increase environmental risks already in the current decade, while the delayed development of the "rubbish" industry and insufficient attention from the state authorities not only deprive the Russian economy of new technological capacities, but also limit the market for additional investments from partner countries. The past year 2020 was rich in the number of records in many areas of the Russian and global economy. The "rubbish" industry was not left out either, with an absolute record for the amount of accumulated rubbish.

According to the State programs of the Russian Federation "Environment protection", calculated for the period from 2012 to 2020, "Development of industry and increase of its competitiveness", the Strategy of production and consumption waste treatment, recycling and neutralization for the period up to 2030, the Strategy of ecological safety of the Russian Federation for the period up to 2025, development and implementation of projects on solid waste disposal (SDW) is a priority in the Russian economy in general and the regions. At present, there are 4 companies in the Republic of Crimea that provide services for disposal, burial and neutralization of biological waste (LLC "Krym-Eco Hydrotech", LLC "Plant for neutralization of epidemiologically hazardous waste", LLC "Ecoservice Group" and State Budgetary Institution of the RK "Crimean Republican Clinical Center of Phthisiology and Pulmonology"), but their activities do not solve the system problem and often have monopoly character. The main problem with the management of biological waste of animal origin in the territory of the Republic of Crimea remains the lack of infrastructure for waste neutralization. While the services of collection, transportation, disposal and neutralization of biological waste of animal origin are not regulated by the state, free market relations in this area, especially in the absence of infrastructure, cannot solve the accumulated problems.

The problem of waste removal and disposal in Crimea is a legacy of the Ukrainian period, when the necessary infrastructure for this was lost and no new infrastructure was created. The problem of MSW collection and disposal is still very acute.
2 Materials and research methods

The methods presented, which consist of minimal loading of waste sorting facilities on the basis of archaic landfill disposal of MSW are morally outdated and need a different recycling approach. At the same time, the acute shortage of industrial recycling capacity has serious consequences, the solution to which has remained only in the plans of the region's executive authorities for many years. The existing problems underline the need for serious measures and solutions today. Designing and constructing new cluster sites, optimising the stages of waste detection, collection and sorting, and transporting it to its final destination in the form of a recycling plant will make it possible:

- Stop the growth of tariffs for the population, improve the quality of waste disposal, reduce the number of unauthorised dumps;
- Increase the number of container sites, bring the existing ones in line with Russian legislation, and sort waste by citizens by type of container for collection;
- Support small municipalities with the necessary federal subsidies for MSW management;
- Stop the massive non-payment by legal entities through direct payments for each legally disposed cubic meter of waste;
- Change the existing type of disposal in the form of archaic landfills, to clustering, through the gradual construction of a waste processing complex;
- Reclassify the budget line 'expenditure' partly as 'revenue'.

3 MSW detection method using remotely sensed data from the earth's surface

The efficient use of natural resources is directly linked to the use of information and telecommunication technologies. An example of means to study the surface of the Earth for MSW contamination are remote sensing (RS) methods of the Earth's surface using constellations of aerospace vehicles. Development of a set of software and hardware tools for the analysis of data received from spacecrafts will serve as the basis for the cluster approach to MSW detection and disposal, thus ensuring the speed of obtaining legitimate information about the state of the environment and the correct managerial decisions by the executive branch of the region. This method implies improving the accuracy of determining the sources of pollution remotely \[21-25\], which is especially important in the development of natural resources of the Black Sea coast and Krasnodar Territory. At the same time one of the main tasks in the field of safe ecological situation in the region is to test the hypothesis of the distribution of multidimensional random variables, assessment of the states of the objects under study and their mapping. The method of MSW detection using remote sensing data implies the use of nonparametric algorithms of multivariate pattern recognition, evaluation of the results, testing the results of the study in the Black Sea water area.

In order to maximize the results of the method of detection of remote sensing of SST it is necessary to create a set of software tools NAMAPR (Nonparametric algorithm multi-alternative pattern recognition), which is aimed at solving problems of processing data obtained from the spacecraft, making management decisions based on nonparametric
A recycling line which enables automated sorting of waste, including: plastic waste, waste paper, mixed waste, and other polymeric materials. The company can produce finished products from recovered polymer: containers of any size and shape, packaging materials, and semi-finished products for construction.

The recycling contains many functions, while forming a complete recycling and disposal cycle. The accumulation of solid waste in the Krasnodar Territory is subject to mandatory weighing, metering and radiation control procedures. Unloading is performed for recycling. Deliveries can be made by rail or road.

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In conclusion of the method it should be noted that the developed interface of the software product is implemented in Python and is based on remote sensing satellite, their sequential processing and presentation of results.

The functionality of the software should include:

1. Manual control of the training sample.
2. Estimation of the condition of the Black Sea objects and their classification.
3. Determination of the degree to which the n signal image belongs to the pollution sources' states according to the directives on the affiliation of detected objects to MSW on the ground surface.
4. Evaluation of scale and weight of the signal image n through a normalizing vector.
5. Processing of the primary RS data providing object classification.
6. Localization, distribution and mapping information using spectral data from the remote sensing spacecraft.
8. Vector, the task contained in module 2 "Classification of detected MSW objects" is solved.
9. Each of the processed signal images evaluated through a normalizing vector.
10. The cluster method for MSW pollution sources' states according to the included directives for the initial data received from a remote sensing spacecraft.

The initial data received from a remote sensing spacecraft contains many functions, while forming a complete recycling and disposal cycle. The accumulation of solid waste in the Krasnodar Territory is subject to mandatory weighing, metering and radiation control procedures. Unloading is performed for recycling. Deliveries can be made by rail or road.
The volume of the plant is designed for a temporary storage period of up to three weeks. The finished briquettes enter the main combustion plant, with two zones. The first zone undergoes thermal treatment at temperatures above 1260°C, which removes harmful substances and dioxins. The second zone represents the afterburning compartments of the generated gases and allows for the complete removal of organic compounds, neutralising the flue gases and lowering their real temperature.

After the combustion at high temperatures, steam is generated in the main body of the boiler, which is fed to the turbine generator to generate heat and power. The useful capacity is delivered to the end-users via newly created or existing energy backbone networks.

4 Results and discussion

In this study, the authors present a science-based methodology for the detection of MSW on the territory of the Crimean peninsula by means of remote sensing. Particular attention is paid to the processes of monitoring and detection of environmental pollution by household and industrial waste. The structure of the software on the basis of nonparametric statistics of the signal images is offered. The result part in the form of algorithmic tool NAMAPR is intended for operative estimation of anthropogenic influences, early diagnostics of infringements in sphere of ecological safety. Testing methods are based on the study of the signal n received from a spacecraft, using the feature vector and the normalising vector. Approbation of the results will allow to manage the bioenergetic potential of natural resources and anthropogenic systems in Krasnodar region. The basis of methodology of formation and functioning of technogenic systems is the principle of ecological safety of the region. A safe environment for man and society is only possible with a comprehensive scientific analysis, early forecasting of the possible damage of harmful industries, respect for natural energy resources, and the full cycle of interaction between such systems. The effectiveness of human (society)-environment interaction is largely determined by the recyclability of waste as a result of the production cycle. At the same time slowing down the processes of depletion of natural energy resources is possible with their full or partial replacement. For this purpose the authors have developed a scientifically substantiated methodology of cluster waste recycling, technology of renewable energy resources based on the stages of deep recycling [33-36]. It is based on principles of controlling physical and mechanical properties of energy materials, complex disperse systems formed in the technological cycle.

5 Conclusion

Thus, new technologies and introduction of the cluster approach in the sphere of processing and utilization of MSW on the territory of the Crimean peninsula provide a unique opportunity for transition from archaic methods of waste management to their industrial processing. The commissioning of the deep processing waste recycling complex will reduce the effects of negative impact on the environment by reducing the volume of buried waste and involving it in economic turnover.

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