MATEC Web of Conferences **106**, 07005 (2017) DOI: 10.1051/matecconf/201710607005
SPbWOSCE-2016

Innovative technologies of liquid media treatment in the system of ecological and sanitary-hygienic control of waste landfills

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Abstract. The article focuses on the scientific and practical aspects of establishing a comprehensive system of environmental compliance for industrial and household waste landfills, including the system of industrial and environmental monitoring and control, modern innovations in the field of instrumental-analytical control of the state of environmental components, new methods of neutralization of complex industrial pollution. Priority is given to wastewater treatment from toxic compounds coming from the surface and drainage water seepage of landfill sites into surface and underground water sources.

1 Introduction

Operation of the disposal facilities, their monitoring and the subsequent restoration of the land plots present a complex modern issue of natural area management. Current situation of the ever-increasing anthropogenic environmental-sanitary and epidemiological burden of many waste disposal sites, which poses an imminent threat to the ecological safety of territories, calls for new approaches to ensure the safe operation of the landfill system.

2 Problem statement

A good rule of thumb is that the implementation of governmental, industrial and public control over the state of the landfills and the state of the environmental safety of areas where waste disposal facilities are located depends on compliance with environmental and other laws in operation of these objects [1,2]. The main violations of rules of landfill operation, sanitary, environmental, technical and other regulations, requirements and standards are: the absence of an efficient system of environmental monitoring of the state of waste landfills; lack or inefficient organization of documentary input, radiation, dosimetry, weight and other controls; lack of control or connivance with the disposal to the authorized

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waste burial of toxic waste hazard class 1-3 detrimental to the disposal of waste hazard class 4 or other secondary raw materials; exceeding the stipulated landfill project and established limits the volume of burial space and the height of waste disposal; falsification of environmental and other statistical reports on the number and quality of waste taken to the landfill, their composition and toxicity; unauthorized seizure of the surrounding areas for the expansion of waste disposal; violation of the requirements when laying, moisture and compaction of waste, laying the insulating layer, layered pouring, filling of buried waste ground, creating conditions for waste combustion; contamination of the sanitary protection zone of the landfill with effluents and emissions in excess of the admissible limits, soil sanitary zone wastes; failure to operate according to the normative legal acts, norms, standards and rules of the system of industrial environmental control and environmental monitoring.

All these violations as a whole lead to large-scale contamination of water, air, soil and vegetation, intimidating the sanitary-epidemiological safety of people. Situation turns to be especially dangerous with pollution of surface and ground water filtration facilities (drainages) and landfills' runoff, containing extremely toxic compounds.

Constant study of the environmental impact of municipal solid waste landfill (MSW) and the conditions of their operation requires the establishment of a comprehensive system of environmental security grounds on the basis of geo information and ground laboratory environmental monitoring of the state of natural resources. This system quickly assesses the current state of the environment after dumping of toxic waste, reveals areas of environmental stress, models and predicts the development of ecological processes, bringing an opportunity to elaborate and implement specific environmental measures that allow to reduce the adverse effects of waste disposal facility on the environment, create landscape-environmental maps and environmental risk maps [1-3].

In accordance with environmental and health legislation a special monitoring project for the landfill is developed, comprising following sections: analytical control status of groundwater and surface water bodies, air, soil and plants, physical and biological contamination in the zone of possible adverse effects of the landfill, the results of which are used to create the process control system at the facility, ensuring the prevention of the negative impact of the landfill on the environment and human health [4]. But the problem is that the system of monitoring and control, in the first place, should be comprehensive and, secondly, must include meet modern international requirements and national standards instruments, devices and structures to monitor the status of all kinds of physical, mechanical, biological and chemical pollution in the likely impact of the landfill area, allowing a high level of quality to evaluate the whole complex of such a negative impact.

3 Discussion and results

The multifaceted qualitative composition of seepage water creates significant ecological and sanitary-toxicological risk and damages components of the natural environment at different stages of the landfill operation with accumulated toxic waste. The combination of expensive methods such as biological, physical and chemical (ultraviolet radiation, adsorption, flocculation, reverse osmosis, coagulation, ozonation, electrochemical oxidation), as well as mechanical wastewater treatment is required to be applied in order to ensure sanitary norms and standards of dumping pollutants in the wastewater.

According to the results of comparative analysis of used waste treatment technologies, the aerobic treatment is used within the acetogenic phase with subsequent aeration tanks nitrification, while anaerobic treatment is implemented in sludge digesters with following denitrification, coagulation, water clarification in settling basins with afterfiltration. These scheme requires water post-treatment using biological multistage ponds to meet the established sanitary norms and rules; bio-sorptional filters followed by additional purification in the biological pond; water or UV ozonation treatment, followed by adsorption with the multilayer filter or micro-water treatment methods, ultrafiltration and reverse osmosis.

During the methanogenic phase the same expensive methods of primary, basic cleaning and additional cleaning of drains are used. Compulsory ozonation is carried out before the stage of biological treatment in order to destroy the colored and bioresistant impurities. However, the presence of extensive amounts of the resulting concentrate after ultrafiltration and reverse osmosis techniques causes a significant problem. Furthermore, at the stages of waste humification and methanogenesis leachate will accumulate bio-resistant impurities and humic compounds which reduce the concentration of metal ions, decreasing the effectiveness of the biochemical treatment [5].

In some countries, particularly in Ukraine, there is developed a scheme, which is based on the method of reverse osmosis with a preliminary two-stage anaerobic-aerobic biological treatment, chemical treatment, settling, sodium hypochlorite disinfection, sand and carbon filtration involving ion exchange step in the Na-cation exchanger and electrodialysis. The disadvantages of certain technologies are multistaging, complexity of the maintenance and control over technological processes, significant consumption of reagents (coagulants, flocculants, acids, alkalis, disinfectants), the necessity for frequent replacement of filters and other the replaceable equipment, and, definetely, the high cost.

The efforts to use the electrolysis technology to clean the seepage water (collection of wastewater in the receiving water, processing water in the diaphragm cell with Sediment iron anodes, mixing the treated water, sediment removal and discharge of treated water) revealed the inability to clean a multi-component composition of such waste effectively to MAC standards and the complexity of its implementation in connection since the unconsolidated sediment formed during this purification process needs to be accommodated. The disadvantages of this technology are: insufficient degree of purification of the organic part of the drainage landfill waters, formation of hazardous waste as sludge during wastewater treatment, incomplete utilization of the sorption capacity and coagulation properties of constantly formed sediment and the redox potential of the exhaust gases and pulverized coke, which is carried away from the anode zone [5].

The next step in electrochemical wastewater treatment, this time in the EU, has become the development of functional nanostructured electrodes based on a porous titanium matrix coated with a nanostructured manganese dioxide (nanocluster) layer. The size of the device is up to 200 nanometers and operating life is 3-5 times more than a life of commonly used electrodes (graphite), aiming to increase the oxidation degree of the hard-oxidized organic components in wastewaters. Technologies of reverse osmosis desalination, membrane and ultrafiltration are being improved [6.8].

Biochemical treatment at a high intensity aerobic processes, being applied after the mechanical pre-treatment (sedimentation, filtration) of the landfill runoff, can reduce biological oxygen demand by 90% and chemical oxygen demand by 80%. However, large amounts of oxygen are required to improve the efficiency of the biochemical processes during the concentrated filtrate treatment in the aeration tanks, which results in significant expenditures of electricity for aeration. The process requires periodic upload and download of active bacterial cultures (activated sludge), which leads to instability during service interruptions. Adding phosphorus, usually in the form of orthophosphoric acid, promotes precipitation and accumulation of heavy metals in their biological muds, which creates additional problems and considerable expenses in the collection and temporary storage of environmentally hazardous waste and its disposal. Storage of sludge, as well as the allocation of large areas for biological treatment of wastewater requires a land allotment, being estimated throughout the country at tens of thousands of hectares. The use of aeration ponds is one of the least labor-intensive and rather effective methods of aerobic treatment or post-treatment of wastewater, which allows to significantly reduce the concentration of ammonium ions and organic matter content (up to 70%). But this biological ponds can be used for cleaning of drainage water landfills containing chemical oxygen demand of less than 350 mg/l, or for final treatment of leachate. Process wastewater bio treatment creates a negative impact on the atmosphere and the health of workers due to the release of pollutants of various classes of danger into the air, having also specific unpleasant smell. Anaerobic methods are most effective at acetogenic phase rich in organic matter, but at methanogenic phase the desired effect can be achieved only if nutrient additives are administered in periodic Digestion tanks (denitrifiers), because inhibit methanogenesis and bio resistant impurities are accumulated at this stage. The main technical and economic challenges using biological wastewater treatment technologies is to ensure such active biomass concentration in the reactor, which would allow optimal use of the entire working volume of construction, reduce the time of wastewater treatment and inefficient labor and energy costs associated with air supply, recirculation flow, processing, transportation and disposal of toxic excess activated sludge. Modern biological treatment systems are usually not able to respond flexibly to changing wastewater discharge modes, their chemical composition on the various phases of operation, cyclicality of the production facilities, the natural temperature fluctuations and short-term or long-term suspension of production [5-8].

The most significant drawback of biological treatment is strict regulation of the maximum permissible inlet concentration of most pollutants in effluents filtrate (ammonium nitrogen, 45 mg/l acetone - 40 mg/l; iron - 5 mg/l; phenols - 15 mg/l; styrene - 10 mg/l; formaldehyde - 100 mg/l xylene - 1 mg/l, and also on a wide range of other organic compounds and metal ions). Exceeding the permissible values (especially petroleum products, synthetic surface active agents, and others.) can fully or partially disrupt the biological treatment process, cause emergency volley discharges of untreated wastewater into drinking water sources. Nevertheless, biological treatment of influent wastewater with the restrictions on the inlet concentration performs poorly in removing basic contaminants found in such effluents (vinyl acetate phthalate, dibutyl phthalate, diethylamine, methacrylates, antimony, strontium, fluorides - no more than 30%, lead, nickel, arsenic, cobalt - 40% aluminum, cadmium, xylene, methylstyrene, mercury, chromium, sulfides, styrene, toluene - no more than 50%, are not removed during biological treatment - sulfates, chlorides , ethylbenzene, chlorinated organics, pesticides, dioxins and several other extremely and highly dangerous compounds) [9] even in a system with mechanical cleaning of seepage water.

According to the analysis it can be stated that the relevance of scientific and practical novelty in the field of cleaning filtration (drainage) and surface wastewater landfills provide technologies that meet the following criteria:

- Based on nanotechnology or modern destructive practices, i.e., on deep transformations of toxic inorganic and organic compounds in low-hazard substances as a result of physical and chemical processes;
- Best available techniques to ensure the higher environmental performance compared to the complex of existing leachate treatment (biological, mechanical, physical and chemical) at all stages (phases) of landfill operation;
- Combining neutralization and sewage treatment in a single set to meet the established standards limiting discharges into water of fishery, with the achievement and maintenance of sanitary norms and rules for wastewater;
- Guaranteeing to the full extent health and environmental safety, eliminating or minimizing secondary negative impact on natural resources and environment (removal of large areas of land for treatment facilities, sludge dumps, reagent storage, filtration load (including toxic

waste), hazardous waste effluent of the treatment process, emissions of pollutants into the atmosphere).

The specialists of JSC "GC NATEK" in cooperation with JSC "VODAR" developed an innovative technology detection and cleaning the full range of pollutants of all kinds of waste water industrial and household waste landfills. Technology of hydrodynamic water and industrial waste treatment is the so-called destructive method, which is based, in contrast to regenerative methods that remove impurities from the water in the solid (adsorption), a gas (desorption) or aqueous liquid (extraction) phase, on making chemical changes in molecular structure and composition of the impurities. It is based on the hydrowave method previously ignored in this field. Its scientific and practical novelty lies in the fact that the physic-chemical processes, which are based on the creation of the processed aqueous media special hydrodynamic regimes in conjunction with exposure to electromagnetic fields, contribute to enhanced and multiple acceleration of chemical reactions in the treated solution. The high technical and environmental performance is achieved by using innovative advanced oxidation technologies AOP (Advanced Oxidation Processes), representing the combined effect of strong oxidants - oxidation with ozone, hydrogen peroxide, radicals OH in cavitation conditions, together with the processing of mechanical impact in the work area of hydrodynamic reactor followed by mechanical separation of a small amount of sludge production [10-15]. The optimal exposure to toxic compounds on the structure level is oxidizing, which is also the most effective tool against pathogenic microorganisms. There is a degradation of organic compounds and water molecules forming strong oxidants O3, H2O2 in the hydrowave treatment unit, where rotating electromagnetic field with ferromagnetic elements and the simultaneous action of cavitation, magnetostrictive, an electric impact on the waste water passed through the working chamber of the hydrodynamic of the reactor. As a result, the rate of oxidation-reduction reactions is increased in the tens of thousands of times. During the effluent treating process, dosing pump feds the appropriate reagent into the hydrowave processing unit, which contributes to the formation of insoluble metal salts with simultaneous coagulation of the organic component of the waste. As a result of these processes the toxic pollutants at the intramolecular level are modified to form low-toxic and nontoxic compounds.

Environmental and hygienic result of these processes is a complete cleaning and disinfection of wastewater ensuring their compliance with the requirements of the state standards GOST R 17.4.3.07-2001; SanPiN2.1.5.980-00 "Hygienic requirements for surface water"; GN 2.1.5.1315-03 “Maximum permissible concentrations of chemicals in water bodies of drinking and household and cultural water use" for the full range of pollutants contained in the wastewater from the facilities of this type (suspended, minerals, surfactants, organic substances; metal ions: aluminum, lead, nickel, vanadium, manganese, arsenic, cobalt, antimony, strontium, potassium, calcium, sodium, iron, cadmium, mercury, chromium, copper, zinc, nitrate anions, nitrite, ammonium, sulphate, fluorides, chlorides, sulfides, dissolved hydrocarbons; organochlorines, dioxin contamination, cyanides, toxic organic compounds: phenol, ethylbenzene, acetone, xylene, toluene, benzene, styrene, methacrylates, mercaptans, methanol, butanol, acetaldehyde, ethylene glycol, pesticides and etc.), of synthetic surface active substances, petroleum products, as well as disinfection of water leasing to normal sanitary and microbiological indicators (pathogenic microflora, fungi, protozoa, bacteria, viruses, etc.) and fishery regulations imposed on the waste water discharged into water bodies. Technological wastewater process line diagram is shown in Figure 1.

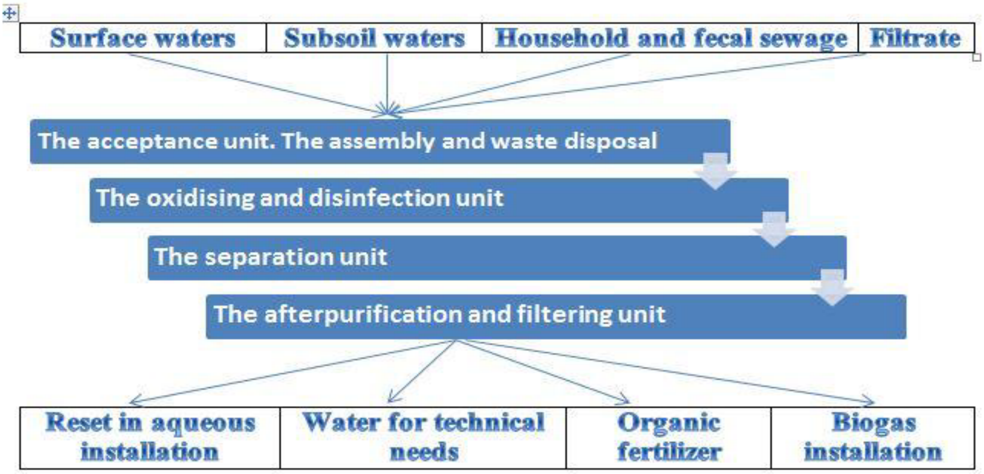

Fig. 1. Technological wastewater process line of waste landfill.

The compact production line with the capacity of 5 cubic meters per day or more occupies about 35-40 sq. m, which is massively smaller space than biological treatment facilities together with mechanical occupies. This production line is energy-efficient: 0.5 kW per 1 m3 of treated wastewater. The ability to connect the water circulation system appears. Application of this technology allows to combine filtration, surface, and household-fecal runoff from the landfill, which helps prevent high costs for construction and purchasing individual treatment facilities, special equipment, and biological, mechanical or physical-chemical treatment systems for removing toxic compounds and impurities from the water. During the wastewater treatment and cleaning process the energy releases, which can be used in the technological process or for other purposes. Ecological and economic efficiency of the installation is confirmed by its successful implementation in various industries and enterprises.

4 Conclusion

The comprehensive, accurate and reliable results of the monitoring and control of the landfill quantitative and qualitative effects on the environment on the basis of the innovative technology of purification of liquid media presented in this article will become a reliable information and analytical base for monitoring, and state and public environmental control. It will also become a supportive tool and analytical basis of comprehensive reliable evaluation of ecological and economic damage inflicted to the components of the natural environment and to the economy of Russia in general. The consistent use of the technology as a part of complex monitoring, control and environment protection measures during the operation of waste disposal facilities gives the possibility to ensure the environmental safety of not only the polygons, but also of the territory of the municipality, the region and the entire country.

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