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MASTER´S THESIS

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Sludge treatment from Chisinau Wastewater Treatment Plant

Tratamiento de los lodos de la Estación Depuradora de Aguas Residuals en Chisinau

Tratamento dos lodos da Estación Depuradora de Augas Residuais en Chisinau

Student´s name: Olga Cernii

Name of Academic Tutor (UDC): PhD Ana Vázquez González

Name of Academic Tutor (TUM): Professor Dumitru Ungureanu

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RETHINKe

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SUMMARY

In the wastewater treatment process, results as residues significant amounts of sludge with rich content in organic matter, with high percentages of nutrients that are necessary for agricultural crops, with high fermentation power that involves unpleasant odors and high virulence and also with high content of heavy metal ions.

In order to reduce significantly the power of fermentation and health risks, resulting through the use, the sludge is stored for long term.

Due to large quantities of sludge resulting from urban wastewater treatment process and similarity of chemical composition with livestock manure, by deeming with it, sewage sludge was proposed as fertilizer and soil improver for different agricultural crops.

The use of sewage sludge in agriculture represents one of the methods of release of the waste and a form of enhancing their content of organic matter and nutrients, being rich in phosphorus and nitrogen. Thus, as a result of the research performed by Institute of Ecology and Geography, Academy of Sciences of Moldova, on use of sewage sludge as fertilizer, was appreciated the behavior of soils and plant production and their beneficial action on crops, emphasizing the implementation of an extensive biological agriculture in our country.

At the same time, for treatment and disposal of sludge which do not meet the requirements for use in agriculture, is used incineration and storage inside wastewater treatment plant or at the ecological ramp for waste storage.

RESUMEN

El tratamiento de aguas residuales se traduce en la generación de importantes cantidades de lodos ricos en materia orgánica, con alta concentración de nutrientes que son necesarios para los cultivos agrícolas, alto poder de fermentación que implica olores desagradables y alta virulencia, y alto contenido de iones de metales pesados.

Con el objeto de reducir significativamente la capacidad de fermentación y los riesgos para la salud, los lodos son almacenados, durante largo tiempo.

Dado la gran cantidad de lodos que se generan como resultado de los procesos de tratamiento de aguas residuales y la similitud de su composición química con el estiércol, los lodos son propuestos como fertilizantes para mejorar los suelos para distintos cultivos agrícolas.

La utilización de lodos de depuradora en agricultura representa uno de los métodos para reutilizar los residuos y una forma de incrementar su contenido en materia orgánica y nutrientes, ya que éstos son ricos en fósforo y nitrógeno. Así, como resultado de la investigación realizada por el instituto de Ecología y Geografía, Academia de las Ciencias de Moldova, con la utilización de los lodos de depuradora como fertilizantes, se aprecia el comportamiento de los suelos y la producción de plantas y su acción beneficiosa sobre los cultivos, destacando la implementación de una agricultura biológica extensiva en nuestro país.

Al mismo tiempo, para el tratamiento y eliminación de los lodos que no cumplen con los requisitos para su uso en agricultura, se emplea la incineración y almacenamiento dentro de una planta de tratamiento de agua o en la rampa ecológica para tratamiento de residuos.

RESUMO

O tratamento de augas residuais tradúcese na xeración de importantes cantidades de lodosricos en materia orgánica, con alta concentración de nutrintes que son necesarios para oscultivos agrícolas, alto poder de fermentación que implica cheiros desagradables e altavirulencia e con alto contido de ions de metais pesados.

Co obxecto de reducir significativamente a capacidade da fermentación e os riscos para asaúde, os lodos son almacenados, durante longo tempo.

Dado a gran cantidade de lodos que se xeneran como resultado dos procesos de tratamentode augas residuais e a similitude da composición química co estiércol, os lodos son propostoscomo fertilizantes para mellorar os chans para distintos cultivos agrícolas.

A utilización dos lodos de depuradora na agricultura representa un dos métodos para reutilizaros residuos e unha forma de incrementar o seu contido en materia orgánica e nutrientes, xaque éstes son ricos en fósforo e nitróxeno. Así, como resultado da investigación realizada poloinstituto de Ecoloxía e Xeografía, Academia das Ciencias de Moldova, coa utilización dos lodosde depuradora como fertilizantes, apréciase o comportamento dos chans, a producción das plantas e a súa acción beneficiosa sobre os cultivos, destacando la implementación dunha agricultura biolóxica extensiva no noso país.

Ao mesmo tempo, para o tratamento e eliminación dos lodos que non cumpren cos requisitos para o seu uso na agricultura, emprégase a incineración e almacenamento dentro dunha planta de tratamento de auga ou na rampla ecolóxica para tratamento de residuos.

CONTENTS

INTRODUCTION

Along with the development and industrialization massive of Chisinau municipality, Chisinau Wastewater treatment Plant that is part of the municipal water supply and seweragesystem, has become reallyan important sludge factory that needs to be treated, dewatered and evacuated from Plant territory. At present, daily volume of sludge production that is accumulated in municipal sewerage system is estimated at about 1500m^3.

The majority of city administrationsfrom Republic of Moldovaare confrontedwith the problem of storage of enormous quantities of various wastes, both at central and local level. If the problem of processing of solid waste is more or less solved, the methods are clear, then the problem of sewage sludge (that is formed as a result of wasteweater treatment) is specific, because their processing and use is much more complicated and expensive, given the large volumes, high humidity, uneven composition and organic substances that decompose rapidly and emanate pestilential odors.

Also, processing of sewage sludgeentails the considerable costs for dewatering, stabilization, disinfection, and the lack of significant calorific power, minimizes their subsequent incineration attractions in economic purposes.

Not long ago, use of opened sludge beds at Chisinau Wastewater Treatment Plant for sludge dewatering and mineralization, was one of the most simple and ineffective methodswhich requires immense areas of land and as a result, leading to environmental pollution, emanating of pestilential odors and formation of unbearably socio-ecological climate for population from Chisinau municipality, towards to local public administration and even to central.

In order to eliminate environmental pollutioncaused by sludge dewatering and mineralization processes, the administration of joint stock company S.A. „Apa-Canal Chisinau” resorted to the use of geotextile bags, „Geotube” type, in which the sludge with organic flocculant is pumped, that have a particular importance. Sludge dewatering at Chisinau Wastewater Treatment Plant through geotextile bags is atemporary measure, used during the design period and construction of new installations at the Wastewater Treatment Plant. Rehabilitation of Chisinau Wastewater Treatment Plant provides implementation of certain processes and advanced technologies for sludge processing, but equally important with higher net operating costs of existing ones.

The experience of the European Union countries in management of sewage sludge formed at Wastewater Treatment Plant, which are processed using the most advanced technologies, installations and equipment, denotes opportunity of using them as organic fertilizer at the cultivation of various crops, fertilization and soil restoration.Also, worldwide, sludge formed in wastewater treatment process at Wastewater Treatment Plantgo through a well-defined cycle: formation, stabilization, dewatering and complete removal from circuit, in order that this being classified as waste. The final process is obtained by 3 well known methods: incineration (burning), storage in special deposits and use as organic fertilizer.

At present, a large proportion of sewage sludge, formed in wastewater treatment process at Chisinau Wastewater Treatment Plant, is in the stage of completion of the processing cycle. Therefore appears the question: What to do with dewatered sludge from arranged deposits from Chisinau Wastewater Treatment Plant, and also with sludge from another Wastewater Treatment Plants from the country, taking into account real economic conditions of Republic of Moldova and of local public administration from Chisinau municipality.

Currently, in Chisinau municipality is lacking heavy and chemical industryand therefore sludge from Wastewater Treatment Plant practically does not contain heavy metals, toxic and chemical substances, so these after dewatering, stabilization and disinfection, immediately from arrangeddeposits could be used as organic fertilizer on arable fields.

However, according to the stipulation of Government Decision no. 1157 of 13.10.2008 on approval of the technical Regulation ,,Soil protection measures into agricultural practices”, those sludge could be used , only with condition of performing of advance deepstudies, that will establish how influence heavy metals, organic and chemical substances from sludge on soil, agricultural crops and how remaining concentration of these substances migrate in harvestedcereals. Concomitant, is necessary to study the influence on animals, the consumption as cereals and plants feed, which were harvested on agricultural fields where was used sludge from Wastewater Treatment Plants.

The execution of these studies were conducted by well-trained specialists in the field, on specific agricultural land, taking into account the soil type, composition and structure, respecting the minimum and maximum doses of sludge and also permanent monitoring of concentrations of heavy metals and mineral substances allowed for the cultivation of these plants.

Thus, taking into account substantial increases in prices for mineral fertilizers, fuel and natural gas, necessary for sludge incineration, it was observed that another solution, at the moment doesn’t exist, following that sludge from Wastewater Treatment Plant to be used, as soon as possible, on the fields as organic fertilizer, which will lead to the release of lands where currently are stored massive amounts of sludge.

1. DESCRIPTION OF THE PLACE WHERE THE PRACTICE HAS BEEN MADE

Taking into account that the Master's Thesis with the title ,,Sludge treatment from Chisinau Wastewater Treatment Plant" has a professional orientation, the practice on this thesis was made in **S.A. ,,Apa-Canal Chisinau"**, that is a joint stock company having its registered address at 38 Albisoara Street, Chisinau, MD-2005, Republic of Moldova.

S.A. ,,Apa-Canal Chisinau" provides the public service of water supply and sewerage in the municipality of Chisinau and it is the largest specialized enterprise in Republic of Moldova.

The establishment of the enterprise on water supply and sewerage in Chisinau was on 12 December 1892, but in 1997 from state enterprise ,,RegiaApa-Canal Chisinau" was created joint stock company S.A. ,,Apa-Canal Chisinau". The company's activity is supervised by Chisinau municipal Council with representation from Municipality.

Currently, in the company about 1944 persons are working: 561 engineers and 1383 laborers.

Figure 1. Joint stock company S.A. ,,Apa-Canal Chisinau"

General Manager performs leadership by the administrative apparatus, which has the following composition:

- Technical and production Direction;
- Economic Direction;
- Public relations Direction;
- Department on quality assurance, control and regulation;
- Secretariat, protocol and public relations Service;
- Human resources Service;
- Service on protection and prevention;
- Computerization Service;
- Administrative and supplies Service.

S.A. ,,Apa-Canal Chisinau" performs the following main activities:

- Public service of drinking water supply and industrial water supply:
  - water catchment – groundwater sources (wells) and surface sources (river Nistru);
  - water pumping;
  - drinking water treatment;
  - exploiting of headraces and water distribution networks.
- Public sewer service:
  - exploiting of sewerage networks;
  - pumping of wastewater;
  - wastewater treatment.
- Public service of thermal energy supply and hot water supply:
  - preparation of hot water;
  - thermal energy production;
  - exploiting of thermal networks.
- Auxiliary activities:
  - design and construction of water distribution and sewerage networks;
  - exploiting of transport;
  - repair of electrical and mechanical equipment;
  - repair of buildings and installations;
  - laboratory investigations for determination of drinking water/wastewater quality.

S.A. ,,Apa - Canal Chisinau" captures water from groundwater sources and from a single river source, the Nistru river, which is located about 20 km east of Chisinău. The supply of Chisinău, relies almost exclusively on the Nistru River. Thus, company has in management 2 Drinking Water Treatment Plants (Nistru and Chisinau).

Also, the company has in management 4 Wastewater Treatment Plants: Chisinau Wastewater Treatment Plant with capacity 340 000 m^3/d, Colonita Wastewaster Treatment Plant with capacity 250 m^3/d, Goianul Nou Wastewater Treatment Plant with capacity 35 m^3/d and Vadul lui Voda Wastewater Treatment Plant with capacity 750 m^3/d.

The analysis of my topic on sludge treatment was made on the basis of technological process at the Chisinau Wastewater Treatment Plant.

Figure 2. Chisinau Wastewater Treatment Plant

Scope of worksconsists in the demonstration ofthe effectiveness of using of treated sludge from Chisinau Wastewater Treatment Plant in agriculture, taking into account stipulations from legislation and different methods of sludge treatment for achieving of necessary efficiency and also encourage the use of treated sludge in agriculture. Therefore, in this work I am going to present a review on sludge treatment and various aspects of sewage sludge used in agriculture.

The following activities were carried out for achieving of goals:

1. Analysis of the technological process at the Chisinau Wastewater Treatment Plant (wastewater and sludge flow);

2. Analysis of curent situation at the Chisinau Wastewater Treatment Plant (status of different facilities, degree of treatment, wastewater treatment efficiency, identification of problems etc.);

3. Analysis of ChişinauWater Supply and Sewage Treatment Feasibility Study and identifying of solutions that are proposed for sludge treatment from Chisinau Wastewater Treatment Plant, and also study of their impact on environment;

4. Research of legislative framework on use of treated sludge in agriculture (European Union and national legislation);

5. Research of different technologies used for sludge treatment, for applying at Chisinau Wastewater Treatment Plant (of such technologies that will allow using of treated sludge from Chisinau Wastewater Treatment Plant in agriculture);

6. Analysis of physico-chemical and bacteriological compositionof sludge (especially heavy metals and pathogens) and research of agronomic benefits of sludge and their effects on crops, soil, plants;

7. Studies on the ecological use of the dewatered sludge from Chisinau Wastewater treatment Plant as organic fertilizer;

8. Obtaining of experimental results on the evolution of heavy metals in plants which grew on soils fertilized with sludge from Chisinau Wastewater Treatment Plant;

9. Research of efficiency of sludge fromChisinau Wastewater Treatment Plant on productivity of agricultural plants;

10. Analysis of different alternatives of possible final disposal routes (especially sludge composting).

11. Final conclusions on obtained results.

2. CHISINAU WASTEWATER TREATMENT PLANT

2.1. General overview

Chisinau Wastewater Treatment Plant (Figure 3) is located in the south – east of city, around 7 km from the city center, near the river Bic, in which is discharged the final effluent. Having low flows, located in the city and finally reaching in the Black Sea, the river would be considered after EU standards as a sensitive area.

Figure 3. Location scheme of the Chisinau Wastewater Treatment Plant

Chisinau Wastewater Treatment Plant is a complex of engineering construction, machinery and communications (Figure 4), which provides classic scheme of biological purification but installations for wastewater treatment were built in successive phases, where the first stage of the Wastewater Treatment Plant was put in operation in September 1968.

Structural status of installations is very precarious but performance of process and final effluent quality should be improved.

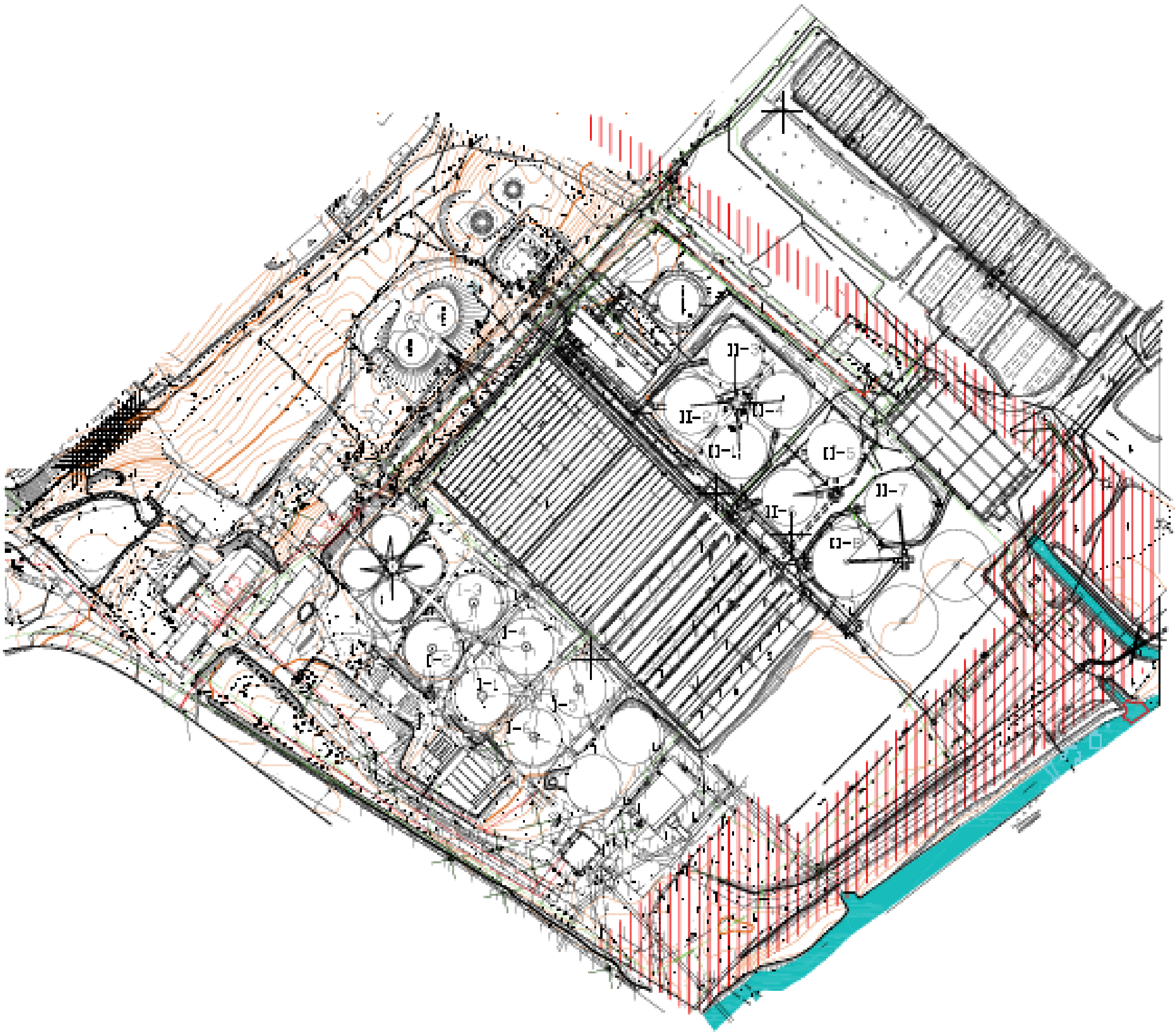


Figure 4. General layout of Chisinau Wastewater Treatment Plant

2.2. Description of the technological process at Chisinau Wastewater Treatment Plant

2.2.1. Wastewater flow

Wastewater from the municipality Chişinău is collected in main collectors: collector on the right bank of the river Bic begins with Ø 800 mm, collector on the left bank of the river Bic begins with Ø 1000 mm; then this collectors pass into dimensions 2500 x 2000 mm, by which, gravitationally wastewater is transported in the receiving chamber of the main pumping Station and by collector under pressure Sîngera – Revaca – Chişinău, whis Ø 600 mm, wastewater is transported in Treatment Plant.

Tha capacity of Chisinau Wastewater Treatment Plant is 340 000 m^3/zi but in fact is 130 000 – 160 000 m^3/zi.

Figure 5. Admission chamber of wastewater at Chisinau Wastewater Treatment Plant

Admission chamber of main pumping station (Figure 5) is equipped with 4 screens, with mechanical rakes, mark MG6T, the dimenssions 2 000 mm x 2 000 mm, width of interspaces – 16 mm, drain grate section - 1,9 m^2 and with 2 screens (brand RCA1918), with centrifugation press, wigth of spaces – 10,5 mm.

Figure 6. Retentions from screens, Chisinau Wastewater Treatment Plant

The screens are designed to retain large amounts of pollutants. The velocity of wastewater between screens rods is 0,8 – 1,0 m/s. Removing of residues on the screens equipped with rakes mark - MG6T, is carried out not less than once per hour into container (Figure 6), that is discharged with wheeled electric hoist by automobiles for further transportation. The quantity of retained residues is 4,5 t/d.

Figure 7. Degritters from Chisinau Wastewater Treatment Plant

Depending on the volume of received wastewater, there are connected manually the required number of pumps. At maximum flow is included one pump (mark 26FV2) and one pump (mark 16FV18), at minimum flow – one pump (mark 16FV18). The pumps pumping wastewater into the distribution channel to grit horizontal – longitudinal with 4 sections (Figure 7). The degritter is used to collect sand and other insoluble inorganic pollutants. The sand from sand bunkers is pumped by hidroelevator as hydromass in geotextile bags, that are located on the platform no. 3 row no. 4.

Subsequently, the wastewater is transported gravitationally in 2 distribution rooms of radial primary clarifiers. Primary clarifiers: D- 40 m, no. 1 – 2 clarifiers with central intake and peripheral outlet; no. 2 – 4 clarifiers with peripheral intake and central outlet.

Primary clarifies (Figure 8) are are intended for submission of insoluble impurities contained in wastewater as suspensions or colloid, ie for clearing of wastewater, which then will be subject to biological wastewater treatment. The raw sludge, decanted in primary clarifies, with scraper is collected into channel for sludge, from where it is pumped for treatment in geotextile bags, 2 – 3 times per day (according to the schedule of technological regime approved by the engineer technologist).

Decanted water after primary clarifies, gravitationally is transported in aerated tanks with activated sludge for biological treatment (Figure 9). Aerated tanks with activated sludge – mixing, each with volume 22,5 thousands m^3 (no. 8, 9, 10) and aerated tanks with activated sludge – piston type, each with volume 12,5 thousands m^3 (no. 1, 2, 3, 4), with a volume of regeneration of 25 – 50 percent. The average sludge dose in aerated tanks with activated sludge is 3÷4 g/l.

Figure 8. Primary clarifier at Chisinau Wastewater Treatment Plant

At the initial stage in aerated tanks is produced mixing of wastewater with activated sludge, which presents aerobic mass with adapted microorganisms. Thus, begins the oxidation of organic pollutants dissolved in wastewater, ie their decomposition into simpler anorganic compounds.

However, there is a process of increasing of the biomass. First takes place the process of destruction of organic compounds slightly oxidized, further of organic compounds with average oxidisability (proteins, fats, carbohydrates - macromolecular substances). After completing the process of oxidation of organic substances easily oxidized, simultaneously with the oxidation of organic substances with average oxidisability, begins the nitrification process: oxidation with oxygen of nitrogen from ammonium salts in intermediate form – nitrites, than in nitrates, which are concomitant nitrogen compounds easily oxidized for flora of natural lakes and for accumulators of dissolved oxygen.

Figure 9. Aerated tanks with activated sludge

Mixture of wastewater and activated sludge, is transported gravitationally in 3 distribution chambers of secondary radial settlers. Secondary radial settlers: D – m, settlers (no. 1; 2; 3; 4) with central intake and peripheral outlet, settlers (no. 5; 6) with peripheral intake and central outlet and settlers with D – 50 m (no. 7; 8) with central intake and peripheral outlet.

After secondary settlers, wastewater is disinfected and thereafter is discharged in emissary (river Bic) with condition to comply with stipulations from Government Decision no. 950 of 25.11.2013 ,,Regulation concerning requirements for wastewater collection, treatment and discharges into sewerage systems and/or natural receiving water bodies for urban and rural localities”.

2.2.2. Sludge flow

The sludge pumped from the primary clarifiers have a humidity of 94 – 96 percent depending on the concentration of suspensions in wastewater and on duration of operation of the pumping cycle. Duration of one pumping of raw sludge is 20 – 40 min. Pumping of sludge is performed by pumps mark FG 450-22,5 which are mounted in Pumping Station no. 1 and no. 2.

Further, it takes place pumping from collectors with fats of the polluting substances, which was removed from the surface of the primary clarifiers with misubmersible facilities. The humidity of this kind of sludge is 98 percent.

Sludge pumping regime is corrected depending on the quality and on flow of wastewater entering in the station, in order to prevent increasing concentrations of suspended matter from the primary clarifiers with the clarified water and with putrefactions formed in settled sludge.

The active sludge in excess from biological treatment stage through the gravity pipe with D=200 mm is evacuated in admission chamber of main pumping station of wastewater, for the purpose of mixing with wastewater transported to the Wastewater Treatment Plant.

Recirculated activated sludge according to its evacuation necessity is pumped from the cycle of biological treatment.

For processing of sludge which is formed at Chisinau Wastewater Treatment Plant, as the result of wastewater treatment, were constructed and put into operation 32,2 ha of sludge platforms. Sludge platforms are designed on the basis of asfalto – concrete and drainage system. Their role is to remove water from sludge and drying of sludge up to humidity 75 to 80 percent.

Figure 10. Geotextil bags from Chisinau Wastewater Treatment Plant

Thus, in order to intensify and streamline the processing of sludge, to decrease surface sludge platforms, as well as solving the problem with odor for reducing of environmental impact, in 2008 was implemented the pilot project on sludge treatment with the use of geotextile bags (Figure 10) and reagents, which are accompanied by the technical sheet, Quality certificate from the manufacturer and Hygiene Certificates issued by the National Center for Public Health.

Current sludge treatment process consist in dewatering of mixed sludge (primary and biological sludge) pumped from primary and secondary clarifiers to the geotextile bags where it is mixed with polymer and kept for about 2 months.

Figure 11. The principle of sludge dewatering in geotextile bags

The process of sludge dewatering with using of geotextile bags (Figure 11) and reagents consist in following steps:

- flocculant receipt from warehouse;
- laboratory testing in order to choose the dose of flocculant;
- preparation of flocculant work solution;
- mixing of raw sludge with technical water to increase the humidity (until the humidity 97,5÷98 percent);
- flocculant dosing;
- flocculation of the sludge particles under the action of the flocculant solution introduced into the treated sludge;
- compacting of sludge in geotextile bags, dewatering and removing of water;
- sludge water filtration through geotextile layer, its collection in drainage system and gravity evacuation into the tank of Pumping station.
- drained waters are pumped with pumps WILO in admission chamber of main wastewater pumping station, located on the territory of the treatment plant, to browse through the entire treatment cycle (mechanical and biological).

The intensity of dewatering processes depends on pumping regime, concentration and dosage of flocculant as well as properties of release of humidity, the quantity and quality of sludge. The sludge is dewaterd in geotextile bags during the 30÷180 days, period after which, the dewaterd sludge coud be transported for storage. Sludge drying is between 15% and 20% after dewatering in geotextile bags. Geotextile bags are opened (Figure 12), but dewaterd sludge is transported by lorries to the deposit (2 ha) that is located at a distance of 200 m of drying beds (32 ha).

Figure 12. Opening of geotextile bags at Chisinau Wastewater Treatment plant

Geotextile bags generates about 87 000 m^3/year of sludge. At a 20% of drying, this equals with 17 400 t/year or 48 t/day. This is in agreement with the assumption that one geotextile bag (600 m^3, 20% of drying) is filled in 3 days (which generates sludge production of about 40 t/day). The lixiviate is collected by the drainage system and is transferred to the second chamber inlet. At the same time, solution of complete sludge removal has not yet been implemented.

3. CHISINAU WATER SUPPLY AND SEWAGE TREATMENT – FEASIBILITY STUDY

3.1. General data

In order to identify and tackle the issues associated with the public service of water supply and sanitation in Chisinau municipality, the company SEURECA, in association with its partners in Republic of Moldova - Business Consulting Institute and SC Water Ingineering SRL - elaborated a Feasibility Study „Chisinau Water Supply and Sewage Treatment”. Thus, Priority Investment Programme (PIP) provides Rehabilitation of Chisinau Wastewater Treatment Plant and construction of one new sludge treatment line.

New facilities proposed to be constructed during PIP, will be designed so that they can be easily integrated in the future treatment plant.

Optimizing of the pretreatment process, dewatering and anaerobic digestion of sludge, will be an effective solution for significantly reduce of unacceptable odor emitted from wastewater treatment station.

Sludge digestion and dewatering will allow the following:

i) reduction in the volume of sludge by removing 1/3 of dry solids;

ii) stabilization of of sludge (currently, the sludge is not stabilized and it is a cause of pestilential odor);

iii) biogas production, which would cover 50% of the energy consumption of Chisinau Wastewater Treatment Plant (including the pumping station upstream).

Before implementing a long-term strategy and sustainable sludge disposal (use in agriculture or ecological storage) it is proposed the continued storage of dewatered sludge in the warehouse recently constructed near the station. It should be stressed that the installation of centrifuges, for sludge dewatering, will prolong lifetime of Treatment Plant with 4 ÷ 6 years.

3.2. Chisinau Wastewater Treatment Plant in perspective

Before the complete reconstruction planned in the future, Chisinau WWTP will be operated using a medium load activated sludge process (treating COD, BOD5 and TSS, but not N and P).

Within the Priority Investment Programme, the construction of new pre-treatment facilities and of a new sludge treatment line is planned (Figure 13). The sludge treatment line will include sludge anaerobic digestion; the good functioning of the digestion requires a steady biological treatment and an efficient pretreatment.

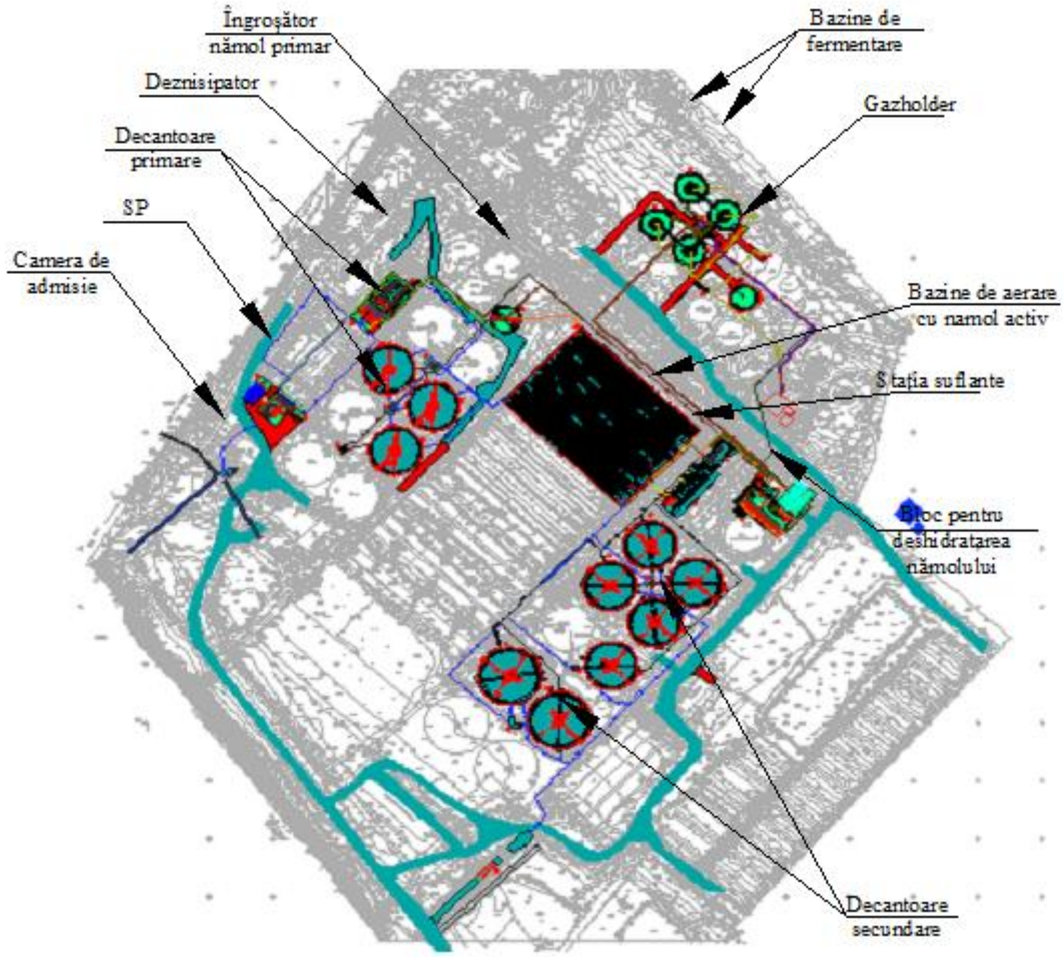


Figure 13. Rehabilitation of Chisinau Wastewater Treatment Plant and construction of a new sludge treatment line (Phase 1)

It is worth pointing out that the Pre-treatment and sludge treatment facilities to be built during the PIP have been designed taking into consideration their future integration in the „New WWTP", which will treat carbon, nitrogen and phosphorus.

As the sludge is to be digested, the final disposal sludge option can be landfilling or agricultural use. The sludge does not require a further pasteurization after digestion.

Joint stock company „Apă – Canal Chişinău" would be authorized to produce the energy to cover its own expenses but would not be authorized to sell the surplus to customers. Anyway, it is expected that the energy production will only cover a part only of the plant's consumption (about 50%).

The sludge digestion requires the chemical removal of phosphorous (instead of biological removal) by ferric chloride injection for instance. Otherwise, the phosphorous that has been captured by the biological process will be released during the digestion stage and recirculated to the head works.

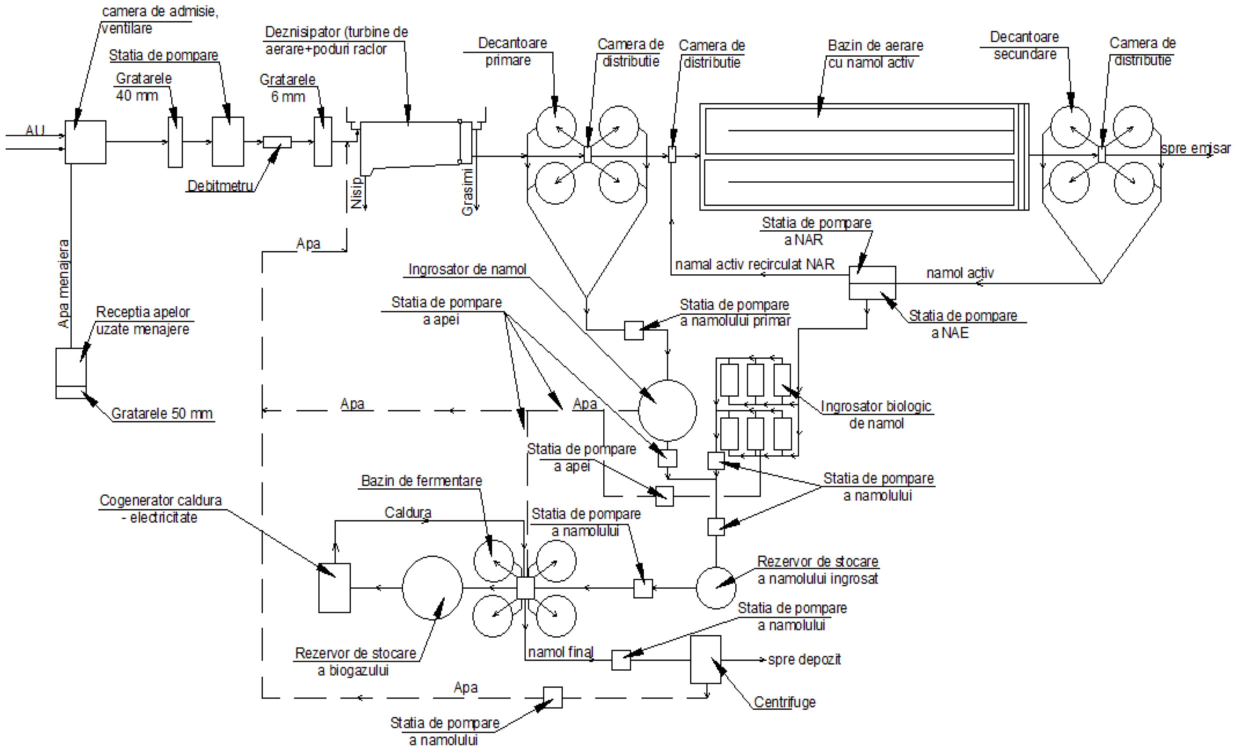


Figure 14. Technological scheme of Chisinau Wastewater Treatment Plant (Phase 1 of reconstruction)

The dewatering of digested sludge results in a wastewater flow return with a high ammonium concentration because half of the nitrogen contained in the sludge is released as ammonium during the anaerobic degradation. This additional ammonium lad at the inlet of the plant will account for approximately 10 % of the raw water inlet load. The return flow recirculated to the head works will therefore have two consequences:

- decrease of the C/N ratio (already decreased by the primary settling);
- increase of the treatment cost to treat the extra load of ammonium.

When the plant is reconstructed (with treatment of nitrogen by nitrification and denitrification), it will be of prime importance to carefully monitor the C/N ratio; injection of methanol or partial by-pass of the primary setters might be required to achieve proper denitrification.

The upgrading of the WWTP comprises two phases:

- In phase 1, a part of the primary settlers, aeration tanks and secondary settlers will be rehabilitated in order to insure a correct level of treatment. New pre-treatment and sludge treatment lines shall be built on the land of the WWTP.
- In phase 2, the primary and biological water treatment will be completely reconstructed.

Implementation of sludge digestion process requires a safe process, namely a good quality of treated water and a stable production of sludge (primary sludge and activated sludge in excess).

Therefore, must be rehabilitated the existing line of wastewater treatment, to ensure reliable operation of the station (process based on activated sludge with average load, only with C removing).

Thus, below are presented the preliminary calculations regarding the construction of a new line for sludge treatment.

Design Criteria

The daily peak sludge production is assessed at:

- 37300 kg DS/d of primary sludge;
- 38000 kg DS/d of biological sludge;
- Total 75300 kg DS/d.

Thickening of Primary Sludge

The primary sludge will be thickened in a static gravity thickener, fitted with picket fence and scrapper

- Design criteria: 37 300 kg DS/day of biological sludge corresponding in the static thickener to 120 kg DS/m^2/day. The hydraulic load is inferior to 1.0 m/h
- Diameter – 20 m
- Expected dryness – 7% (70 g/L)
- Quantity of thickened primary sludge – 532 m^3/day.

Biological sludge thickening

The biological sludge extracted from the secondary clarifies will be thickened in belts thickeners:

- Design criteria: 38 000 kg DS/d of waste activated sludge, corresponding in the belt thickener to 150 kg/h/mL. The belt thickener will work 20 hours a day

- 6 belt thickeners of 2,5 m width will be installed. The length is 4 m (3 m for the belt)
- Expected dryness = 5% (50g/L)
- Quantity of thickened biological sludge – 760 m^3/day.

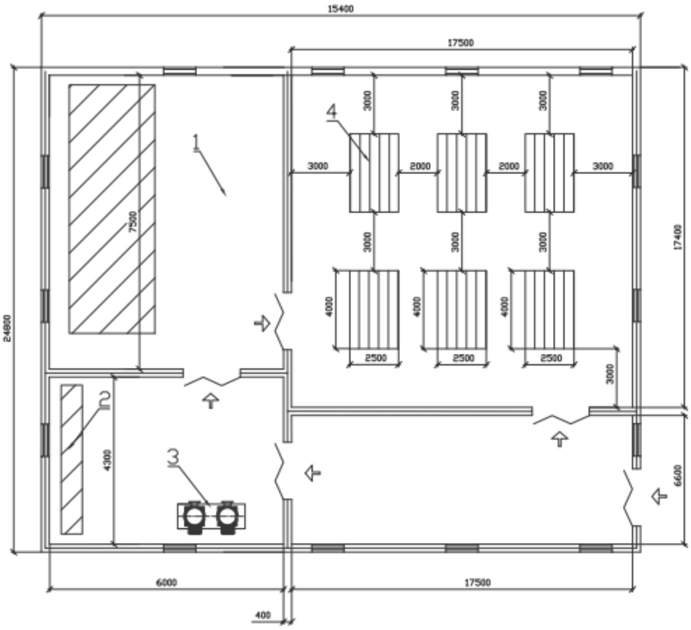


Figure 15. The building for thickening of biological sludge

1 – chamber for the preparation of the polymer; 2 – room with electrical panels;
3 – biological sludge thickener

Mixing tank

The thickened primary and biological sludge will be then mixed in a tank of 20 m^3. The total thickened sludge is 1 292 m^3/day.

Digestion

The mixed sludge is then pumped to a sludge digester (Figure 16), closed and heated tank:

- Design criteria: Retention time = 20 days. Quantity of sludge = 1 292 m^3/day.
- 4 digesters of 6 500 m^3 will be installed with diameter = 24 m and height 15 m.
- Expected TSS reduction = 30%
- Quantity of sludge aflter the digestion = 52 710 kg DS/day (40,8 g/L).

Dewatering of the sludge

After the design process, the sludge will be dewatered in centrifuges before the final disposal:

- Design criteria: the centrifuges will be working 12 hours per day; the quantity of sludge is 52 710 kg DS/day

- 4 centrifuges will be installed (3+1), with a capacity of 45 m^3/h
- The sludge will be stored in a silo (3 days of storage possible) before being taken to the final disposal site.

Gas holder

The gas produced in the digesters will then be stored in a gas holder (Figure 17):

- Design criteria: maximum biogas production = 21 000 Nm^3/day
- One gas holder with a flexible membrane of 5 300 m^3 will be installed.

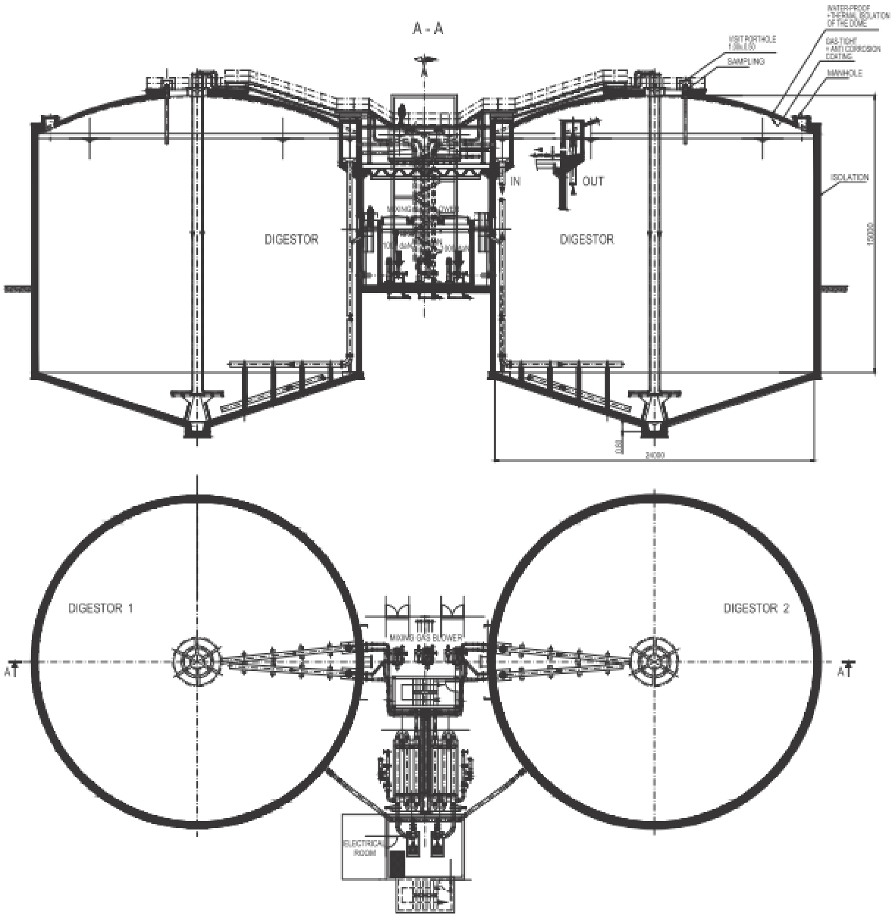


Figure 16. Sludge digester

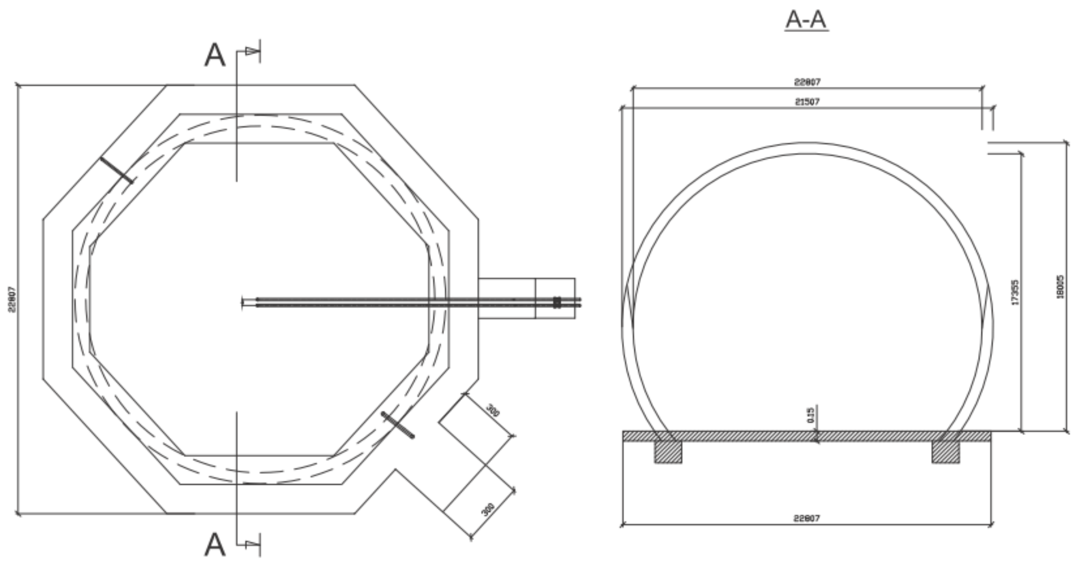


Figure 17. Gas holder

Co-generation unit:

The existing operation building (with the boilers, the heat exchangers, the gas compressors, etc.) will be used. It will produce the heat necessary for the digesters and electricity to be consumed on the site of the Wastewater Treatment Plant.

Sludge recirculation line:

The biological sludge will be recirculated after the secondary settlers upstream of the aeration tanks.

Moreover, the water issued from the different sludge treatment unit will be recirculated to the pre-treatment unit, before the grit chamber: it includes the thickening, digestion and centrifugation processes.

- 3 pumps with 150 m^3/h will pump the biological sludge to the belt thickeners. They will work 20 hours a day.
- 3 pumps with 1000 m^3/h will pump the mixt liquor from the secondary settlers to the aeration tanks. They will work 24 hours a day.
- 3 pumps with 150 m^3/h will pump the primary sludge to the static thickener. They will work 12 hours a day.
- 3 pumps with 150 m^3/h will pump the sludge from the mixing tank to the sludge digestion. They will work 24 hours a day.
- 3 pumps with 100 m^3/h will pump the sludge from the digesters to the centrifuges. They will work 12 hours a day.

3.3. Expected positive environmental impacts of the Prioritary Investement Programme implementation

Implementation of anaerobic sludge digestion and biogas recovery and valorisation will result in an energy production of around 35 000 kWh/day (13 MWh/year), that is more than 50% of the energy required by all the treatment works.

Also, the implementation of the anaerobic digestion of sludge will result in a reduction by 25 to 30% of the sludge dry mass by degradation of organic (volatile) matters. Moreover, the digested sludge will be almost free of faecal bacteria and virus (but not of helminth eggs) and without bad odours.

After dewatering, the sludge will reach 20 to 25% Dry Solids (DS), and therefore more easy to handle, transport and spread into the soil by usual agricultural machinery such as muck spreader. It should be remembered that currently the sludge processed in geotextile bags can only reach 15 to 20% DS.

3.4. Environmnetal impact during the operation stage

3.4.1. Impact on soil – soil pollution from sludge deposit

Even if, as compared to the present situation, the sludge treatment proposed in the PIP (dewatering an anaerobic digestion) is indubitably a real improvement it terms of quantity, odour emission and pathogen content, it will not reduce the sludge toxicity associated with heavy metals and other persistent organic pollutants (POPs). Both proposed outlets for treated sludge i.e. landfilling or agricultural use, will increase the concentration of heavy metals and other pollutant in soil. The pollution level will be higher with landfilling than with agricultural land spreading but if sludge is continuously spread into agricultural land the heavy metal concentration in soil will increase gradually. At present, the sewage network of Chisinau does not receive effluent of major polluting industries, and the heavy metal concentration of wastewater is not expected to be a significant concern, at least for biological treatment.

3.4.2. Impact on air

Biogas generated by anaerobic digestion of sludge is mainly composed (up to 90%) of methane (CH_4) and carbon dioxide (CO_2) which both are greenhouse gases (GHS) but not toxic and not harmful for the local environment and consequently not considered as air pollutants. Biogas also contains is very low proportion (less than 1/1000 in volume) hydrogen sulphide (H_2S) and other sulphur compounds, ammonia and a large number of organic gases such as aromatic hydrocarbon, volatile chlorinated organic compounds, as well as heavy metals (few $\mu g/m^3$), a part of which being classified as carcinogenic or toxic. If the biogas is released into air from the top of digester, the initial very low concentration and the plume dilution are expected to lesser the health impact on the (remote) surrounding population to an acceptable level. No study has demonstrated any adverse health effect of biogas emission on general population. Health problems may however occur among the workers in case of acute exposure to biogas, in case of rupture of biogas transporting pipe.

Actually, biogas is generally collected and burned either in open air (flaring), or in boilers power generators or heat and power co-generators. These last valorisation processes of biogas often enable the need in power of the Wastewater Treatment Plant to be fully covered, at least out of the coldest months. The Prioritary Investement Programme provides for the use of the biogas to fuel the existing cogeneration turbine installed in the Wastewater Treatment Plant and still operational although it has not been operated since several years ago. This use requires an enrichment and purification treatment of biogas for the removal of CO_2, water, H_2S, ammonia as well as particulate matter. This treatment will also eliminate the vast majority of trace toxic gases. Reodorization of biogas will be necessary to make any gas leak detectable.

3.4.3. Impact on water

After landfilling or agricultural land spreading heavy metals will migrate down to the shallow groundwater together with the rain water infiltration but their mobility will be significantly reduced by the rather high pH of the soil (except for arsenic). Given the large thickness and the quite low porosity of the geological layers protecting the deep water, the deep ground water (used for water supply) is very unlikely to be contaminated by heavy metals and other persistent pollutants released by sludge.

Certain unsuitable conditions of land spreading (sloped area, frozen soil, etc.) may cause the direct discharge of the sludge into the surface waters, which will likely result in increased organic matter and heavy metal concentration.

3.4.4. Impact on human environment

The operation of the rehabilitated Wastewater Treatment Plant will increase the vehicles circulation for the haulage of both inputs (polymer, lime and other chemicals) and treated sewage sludge to be landfilled out of the Wastewater Treatment Plant site or spread into agricultural plots. Because of both digestion and dewatering, the volume of sludge will be reduced to less than 150 m^3/day, that are 10 to 20 trucks/day. Actually, in case of agricultural valorisation of sludge, the number of vehicles may dramatically increase due to the restricted period of application and the size of the farmer's trails. Nevertheless, no major traffic jams or other traffic problems are expected to occur due to the sludge transportation. The location of the Wastewater Treatment Plant in an industrial area at the eastern edge of Chisinau city will prevent sludge transporters to cross the most populated areas of the city.

Although the mesophillic digestion process undergone by the sludge eliminates a large part of pathogens, the digested will not be considered as safe product. As a consequence, if sludge is used for agriculture with basic precautions, there will be a possible risk of the farmers spreading them on their plots and possibly for the consumers of crops which have grown on these plots.

4. LEGISLATIVE FRAMEWORK FOR THE USE OF SLUDGE FROM WASTEWATER TREATMENT

4.1. European Union legislation

The main legislative act of EU, which regulates management of sewage sludge, when it comes to their use in agriculture, is Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.

For the purposes of this Directive, sludge means:

1. residual sludge from sewage plants treating domestic or urban waste waters and from other sewage plants treating waste waters of a composition similar to domestic and urban waste waters;
2. residual sludge from septic tanks and other similar installations for the treatment of sewage;
3. residual sludge from sewage plants other than those referred to in (1) and (2).

The Council Directive 86/278/EEC was adopted for the following reasons:

- the need to provide a special regime for this type of waste, also giving the security by ensuring the protection of humans, animals, vegetation and the environment against any adverse effects caused by the uncontrolled use of sewage sludge;
- the need to establish the first community measures in soil protection;
- sludge can have valuable agronomic properties and it is therefore justified to encourage its application in agriculture provided it is used correctly; whereas the use of sewage sludge must not impair the quality of the soil and of agricultural products;
- some heavy metals may be toxic to plants and also to man through their presence in crops and whereas it is necessary to lay down mandatory limit values for these elements in the soil;
- the use of sludge should be prohibited when the concentration of these metals in the soil exceeds these limit values;
- soil concentration in these elements must not exceed limits, due to the application of sewage sludge. To avoid such events, or will be limited annual doses of sludge that can be applied to agricultural soils, or to watch to not to exceed the applicable limit of heavy metals in soils that could reach based on an average ten-year

- sludge must be treated before being used in agriculture; whereas Member States may nevertheless authorize, on certain conditions, the use of untreated sludge, without risk to human or animal health , if it is injected or worked into the soil;
- is necessary that between the date of application of sludge on agricultural soils and the date on which the animals are taken out for grazing, are harvested forage plants, etc., have to be a period of non use of this land to avoid direct contact with the ground; use of sewage sludge in fruit and vegetable crops during the growing season, except fruit trees should be banned;
- sludge should be used under conditions which ensure that the soil and the surface and ground water are protected, in accordance with Directives 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States and 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances;
- it is necessary to control the quality of sewage sludge and the soils on which they are used, to perform analysis on them and to communicate the results to users.

Regarding heavy metals, Council Directive 86/278/EEC provides values of their concentrations in soils receiving sewage sludge, concentrations in sewage sludge destined for agricultural recovery (Table 1) and maximum annual quantities of such heavy metals which may be introduced in agricultural soils.

Table 1: Limit values for concentrations of heavy metals in soil

No.	Parameters	Limit values, mg/kg dry matter
1.	Cadmium	20 – 40
2.	Copper	1000 – 1750
3.	Nickel	300 – 40
4.	Lead	750 – 1200
5.	Zinc	250 – 4000
6.	Mercury	16 – 25
7.	Chromium	–

Council Directive 86/278/EEC encourages the use of sewage sludge in agriculture and regulate it so as to prevent damage to vegetation, animals and man. For that is forbidden to use of untreated sludge on agricultural land. Treated sludge is defined as a product that has undergone biological, chemical, thermal, long-term storage or any other appropriate process to reduce its fermentability and health risks in case of their use.

Council Directive 91/271/EEC concerning urban wastewater treatment refers to the collection, treatment and disposal of urban wastewater and treatment and evacuation of wastewater from certain industrial sectors. Directive encourages the recycling of sludge coming from wastewater treatment. This Directive requires that sludge from wastewater treatment should be treated and used properly and should be the subject to general rules of registration and authorization.

The proportion of sludge recovered by agriculture in has not changed since 1995 and it is around 40%. However throughout this period was a continuous increase in the production of sludge as Member States have implemented the requirements of the urban wastewater treatment Directive. As a result, the actual quantities of sludge that are scattered on the land increased gradually. For example, Norway uses in agriculture over 90% of sludge produced from Wastewater Treatment Plants.

4.2. National legislation

Legislation of Republic of Moldova in this are is adjusted to EU Directives, through Government Decision no. 1157 of 13.10.2008 on approval of the Technical Regulation ,,Soil protection measures into agricultural practices”, where art. 11 provides that sludge from Wastewater Treatment Plants could be used in agriculture, so that the accumulation of heavy metals in the soil does not lead to an exceedance values - limit of concentrations accumulated during 10 years on the same area may not exceed. In this Regulation are ofered methods of sludge and soil analysis. Moreover, the use of sludge is prohibited on:

- grassland or forage crops at least three weeks before the start of pasture and harvesting forage crops;
- land planted with vegetables and fruit during the growing season, except of fruit trees;
- ground intended for the cultivation of vegetables and fruits, for a period of 10 months before harvesting and during harvest.

However, this Government Decision does not provide responsibilities and tasks of the parties stakeholders involved in the management of sewage sludge.

5. GENERAL OVERVIEW ON SLUDGE TREATMENT PROCESSES

Sludge treatment processes are very diverse and therefore may not be establish universal recipes and technologies, but for each treatment plant must be studied properties of the sludge which will be subject to processing.

The basis of all sludge treatment processes are two distinct processes, namely the digestion of sludge and dewatering of sludge. Between these two main processes may appear different variations or combinations of methods whose implementation is differentiated depending on local conditions, the quantity and quality of sludge, the availability of land for the installation and drying and storage platforms, etc.

Classification of sludge treatment processes (Table 2) can be made according to several criteria, namely:

- reducing humidity criteria;
- reducing organic composition criteria;
- processing cost criteria.

Table 2: Classification of sludge treatment processes

No.	Classification group	The method of processing
1.	A. Conditioning	1. Anaerobic or aerobic digestion 2. Gravity or flotation thickening 3. Chemical conditioning 4. Thermal conditioning
2.	B. Dewatering until 50 – 80% of humidity	1. Sludge ponds 2. Dewatering beds 3. Mechanical dewatering (static) 4. Mechanical dewatering (dynamic)
3.	C. Dewatering until 26% of humidity	1. Thermal dewatering 2. Landspreading
4.	D. Final processing for recovery and reintegration into the natural environment	1. Incineration 2. Composting with plant waste 3. Soil conditioning agent 4. Permanent dump 5. Accumulation for subsequent recovery

Processes specified in the first group in fact shall be considered as a step of pretreatment of sludge to reduce a lower limit of humidity, but can occur changes in the sludge structure.

In the second group are summarized dewatering natural processes: mechanic, with a significant reduction of sludge humidity. The processes of this group is usually combined with the processes from first group.

In the third group of processes are included processes that lead to the advanced reduction of sludge humidity (up to a humidity of 25%), some of them being also the final processing solution.

The last group are presented finishing processes which must ensure reintegration of sludge in the environment without polluting, or valorization of their potential fertility in agriculture

After analyzing of Table 2, we conclude that processing procedures lead to the following types of sludge:

- stabilized sludge (aerobic or anaerobic);
- dewatered sludge (natural or artificial);
- sanitized sludge (through pasteurization, physicochemical treatment or composting);
- fixed sludge, resulting through solidification, in order to immobilise toxic compounds;
- ash resulted from the incineration of sludge.

Table 3: Examples of processes for treatment of sewage sludge applied worldwide

Process	Description
Pasteurization of sewage sludge	Minimum 30 minutes at 70°C or minimum 4 hours at 55°C (or other appropriate conditions), always followed by a mesophilic anaerobic primary fermentation
Thermophilic anaerobic digestion	The average period of maintaining in fermentation is at least 7 days, but temperature should be 55°C at least 4 hours
Composting (bulk or aerated pile)	The compost must be kept at 40°C at least 5 days, and for 4 hours, in this period, will need to achieve a minimum 55°C inside the the pile, followed by a maturation period adequate to ensure that the composting reaction is complete sustainable
Stabilization with calcium carbonate ($CaCO_3$)	The addition of calcium carbonate make to increase the pH of of sludge to about 12. Thereafter, sludge can be directly used on the land (pasty sludge applied by agricultural machinery for applying of organic fertilizers)

Keeping in a liquid state	Liquid sludge disposal is for a minimum period of three months
Sludge dewatering and storage	Conditioning of sludge with calcium carbonate or other coagulants followed by dewatering and storage for at least 3 months, is made if sludge has been previously subjected to a process of primary mesophilic fermentation and storage for a period of at least 14 days

Normally currently, raw sludge from Wastewater Treatment Plants previously are processed by anaerobic digestion (to afford the biogas), followed by natural or artificial dewatering process and final their valorisation in agriculture, as fertilizer, but only if it meets the bacteriological point of view. By anaerobic digestion takes place and a mineralization of organic substances that are harmless to the environment and then is obtained biogas.

6. SLUDGE VALORISATION AND FINAL EVACUATION

Sludge valorisation is not just urban wastewater treatment, it should be considered only as a mean of sludge removing from the Wastewater Treatment Plants without having a negative impact on the environment.

Sludge from urban Wastewater Treatment Plants contain, in addition to fermentation gases, some substances that can be realized. Some of them, such as plant nutrients for soil and plants have found a wide use. Instead, the recovery of metals and other useful substances applies particularly to sludge from industrial wastewater.

Given that the volume of industrial and human waste is increasing, municipalities and government agencies worldwide are placed in situation, obligatory to find sustainable ways to eliminate them in the environment. At present used methods (Figure 18) refers specifically to their application on agricultural land, composting and use of compost from sewage sludge as fertilizer material for horticultural crops or as a source of organic matter and nutrients for agricultural land.

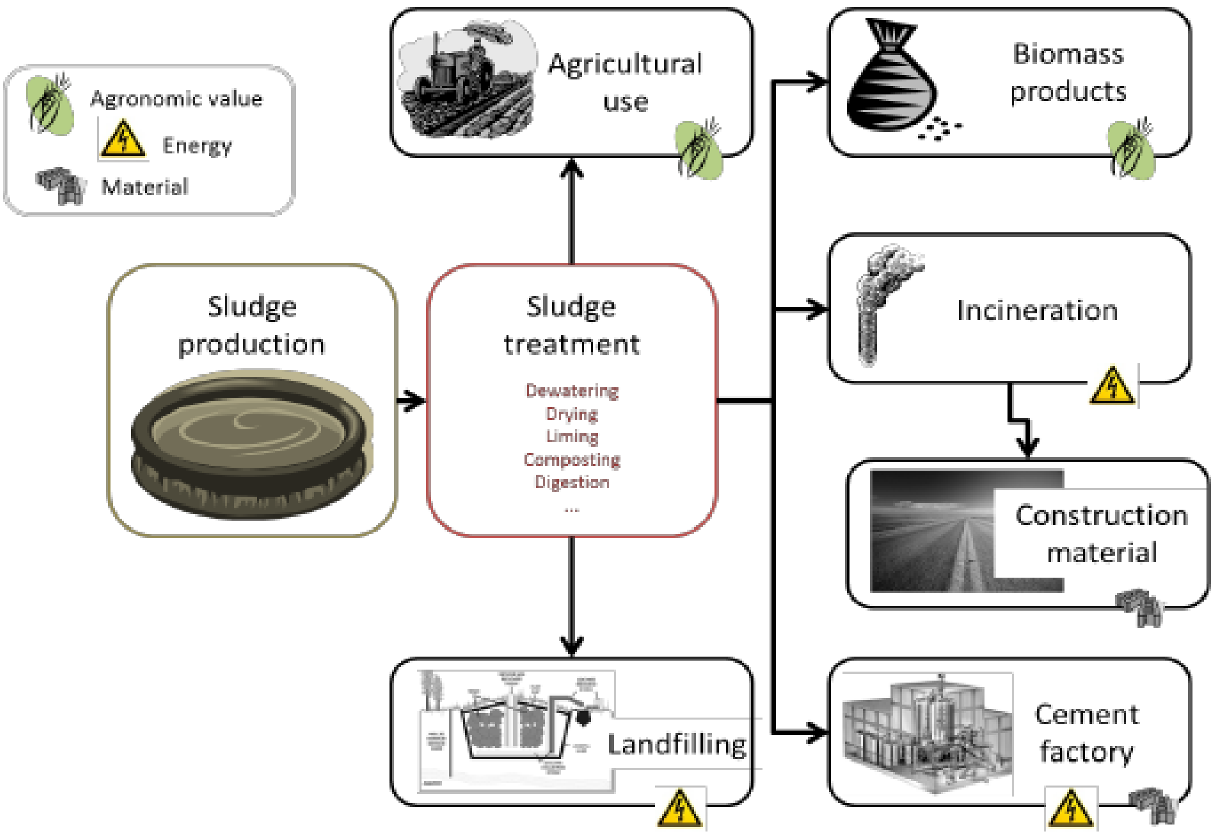


Figure 18. Possible final disposal routes

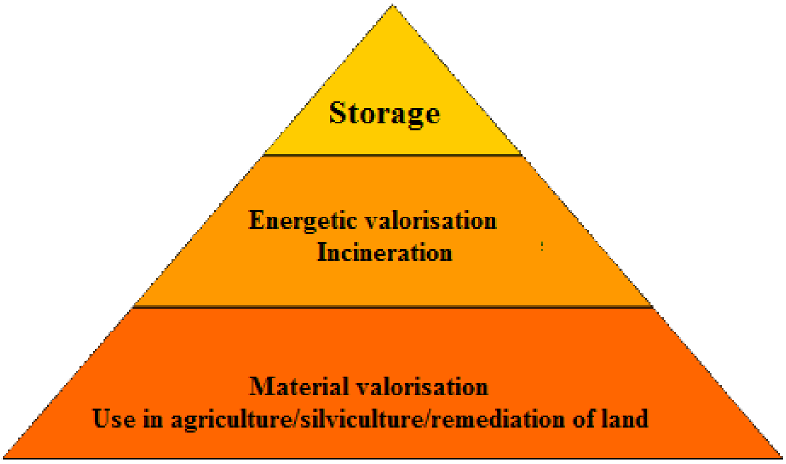


Figure 19. Hierarchy of sewage sludge management

Thus, according to the hierarchy of waste management, sewage sludge must be exploited as many times as possible before final storage. Because sewage sludge contains compounds with useful agronomic properties (organic matter, nitrogen, phosphorus, potassium, calcium, magnesium microelements, etc.), the main way of exploiting is in agricultural use and is not excluded possibilities of using in sylviculture or remediation of degraded lands (Figure 19).

Except the situation when is injected or incorporated into soil through any other ground works, sewage sludge should be the subject of a biological treatment process, chemical or thermal, long-term storage or any other appropriate process, designed to reduce the degree of fermentability and health risks before being applied to agricultural land.

6.1. Sludge valorisation in agriculture

6.1.1. Physicochemical and bacteriological composition of sludge

Management of waste from processing of urban wastewater – known as sludges, is one of the biggest problems in large human communities.

The term ,,sludge resulting from urban wastewater treatment” is used in many specialized works, including national and international regulations.

Recently, this term was replaced by the ,,biosolids” (Figure 20), because it more accurately reflects the beneficial essential characteristics of the sludge for soil amelioration.

For use in agriculture are known several methods of sludge processing, such as sludge thickening, digestion (aerobic or anaerobic), conditioning and dewatering, etc.

Figure 20. Valorisation of sludge in agriculture

Applying of sludge from urban wastewater treatment on agricultural soils is a common practice in many countries in the world (more than 50% of the sludge production in the USA and more than 30% in EU), while in Republic of Moldova is recording a shy beginning.

In this context, due to negligible quantities of sludge that is produced annually, has been attempted an efficient way to recovery, but in the same time ecological, of sludge resulted from wastewater treatment and namely use in agriculture.

Thus, sludge – the main waste from processing of wastewater, is a biosolid consisting of over 70 chemical elements and an impressive number of organic compounds, which continues to grow in terms of improving of analysis methods.

Its use for the bioremediation of soils, requires first knowledge of physicochemical and bacteriological properties of biosolids, in conditions when the risk and benefits of applying in agriculture are directly dependent on the analytical and the temporal variability of the composition of sludge.

On the other hand, as is known, sludge is a complex mixture of chemical and biological contaminants, and knowing the physicochemical and bacteriological composition of sludge for soil amelioration, is important to take decisions on their use in sustainable agriculture, namely:

- ✓ if practical application is technically feasible;
- ✓ effective cost of sludge applying;
- ✓ amount of sludge per area unit applied annually or cumulative;

- ✓ monitoring of system soil – plant – wateră to avoid the occurrence of the pollution.

In the literature there is a sufficient amount of information on the quality of sludge from urban wastewater treatment, to be used for soil amelioration, in conditions of sustainable agriculture.

Of the many aspects of the sludge application in agriculture interdependent with its composition, hereafter are mentioned only those segments that controls and limits the use of sludge from municipal wastewater treatment namely:

- ✓ pH;
- ✓ organic matter;
- ✓ macronutrients;
- ✓ micronutrients;
- ✓ organic chemical compounds;
- ✓ potential risky pollutants;
- ✓ pathogenic agents.

Compoziţia nămolului este dependentă în principal de caracteristicile apelor uzate, fiind influenţate însă şi de tratamentele aplicate în timpul procesării.

The composition of sludge is mainly dependent on the characteristics of wastewater, being influenced by treatment technologies applied during processing.

6.1.2. Studies on ecological use of the dewatered sludge from Chisinau Wastewater Treatment Plant as organic fertilizer

It is widely accepted that the residual organic wastes (the type of sewage sludge) have important contents of organic matter and nutritional elementswhich could be harnessed by application to farmland. The process of recycling of different types of waste materialsby introducing in agriculture, after an extremely important preparatory phase on sanitation mode, that is treatment and processing, aroused interestboth the scientific community and practitionersand in the local administration and not least the organizations and institutions of environmental protection.

In the spring of 2014 researches were initiated on use of dewatered sludge from Chisinau Wastewater Treatment Plant as organic fertilizer (Figure 21), performed by specialists on experimental lands of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova (Figure 22).

FigurE 21. Research on the use of sludge from Chisinau Wastewater Treatment Plant as organic fertilizer

The basic objective of the research is the recycling of sewage sludge on agricultural soils, through their harnessing, as a productive method and respectful for environment.

Other objectives of this research are:

- Physic -chemical characteristics of sludge from Chisinau Wastewater Treatment Plant;
- Establishment of optimal dosage of sludgeas soil ameliorant under various crops;
- Determining the suitability of soils (heavy metal content) at the application of sludge generated from wastewater treatment;
- Establishment of agricultural benefits as a result of applying of sludge;
- Prevention of heavy metal pollution of environmental components (water, soil, plant) in relation to trophic chain soil – plant - man.

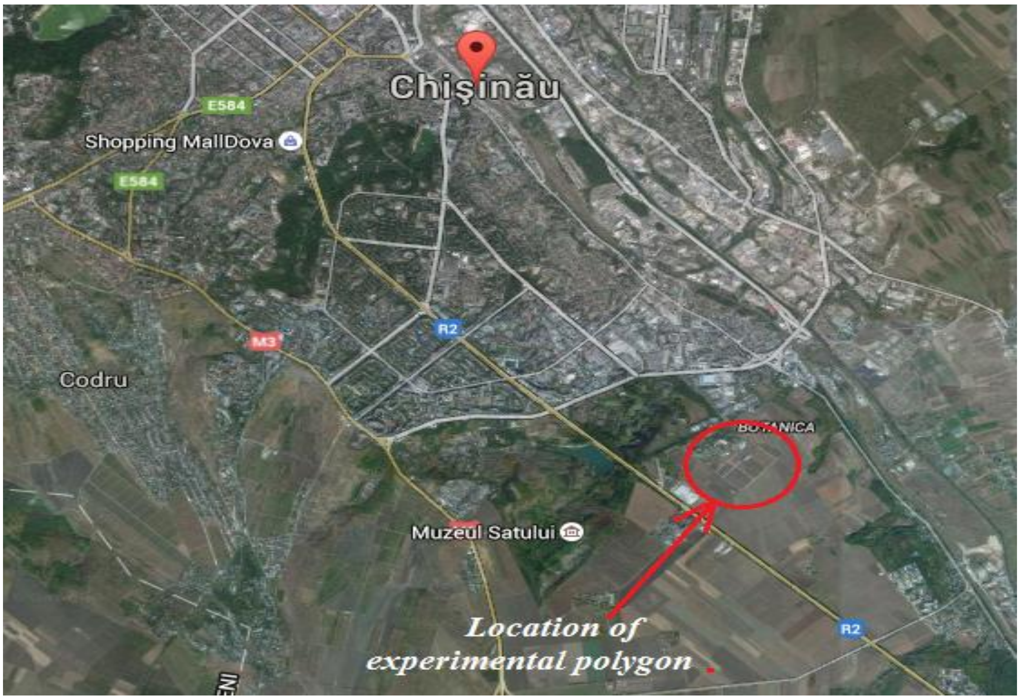


Figure 22. Situation plan of experimental polygon

Methods of sampling for analyze:

1. Soil sampling.

Soil samples for analyzes should be constituted through mixing of 25 individual samples harvested from some elementary plots, which surface is set according to the geomorphological conditions, coating structure of the ground and the mode of land use. The depth of harvesting of samples is 0 – 30 cm in case of annual crops and 0 – 30, 30 – 60 in case of multi annual crops.

2. Sludge sampling.

The sludge should be sampled after treatment, but before administration in soil.

3. Methods of analysis.

The heavy metals analyzes should be performed after mineralization with strong acid (HCl). The reference method of analyzes should be spectrophotometry with atomic adsorption, but detection limit for each metal must not be higher than 10 % from appropriate limit value.

Sludge spreading is made only in periods when is possible normal access on field and sludge incorporation into the soil immediately after application.

In sludge use should be respected the following rules:

a) should be considered nutritional needs of plants;
b) not to compromise the quality of soil and of surface water;

c) the value of pH from soils on which will be applied the sewage sludge, should be maintained above 6,5 UNT.

Chemical analysis of soil and sludge samples was performed according with following normative documents in force:

- content of humus (%), State Standard 26213-91;
- content of mobile phosphorus (mg/100g soil), State Standard 26205-91;
- content of exchangeable potassium (mg/100g soil), State Standard 26423-85;
- content of ammonia nitrogen (mg/100g soil), State Standard 26489-85;
- content of nitrate nitrogen (mg/100g soil), State Standard 26951-86;
- content of mobile forms of microelements (mg/kg), Methodical indication;
- pH, State Standard 26423-85;
- Radioactivity Sr^{90} (Ci/km), State Standard OCT 100-70-95;
- Radioactivity Cs^{137} (Ci/km), State Standard OCT 100-71-95.

6.1.2.1. Risks of sewage sludge

Application of of sludge on agricultural soils is regulated by Council Directive 86/278/EEC. It is recommended annually, average 30 years, may not to apply on agricultural land more than 0,15 kg/ha/year of cadmium, 6 kg/ha/year of copper, 3 kg/ha/year of nickel, 6 kg/ha/year of lead, 18 kg/ha/year of zinc and 0,1 kg/ha/year of mercury.

In setting of these limits was considered that sewage sludge is not the only one source of heavy metal pollution of agricultural soil. If land where sludge is applied is very low in nutrients (for example land polluted with oil, stockpiles of ash andphosphogypsum, etc.), it can be accepted that applying of sludge doses should take into account the need for culture of nitrogen, the need for soil of organic matter, etc., so elements that require the application of doses that exceed the maximum annual amount of heavy metals. The use of sewage sludge in the soil amelioration enables high annual dose application of sludge, but so calculated that in 30 years not to touch the maximum allowable amounts for pollutant elements in soil.

The maximum permissible doses in the process of soil improvement will take into account the nitrogen need of culture, in order to exclude any risk of pollution of surface and groundwater with nitrates.

Recycling of sludge on agricultural land is generally regarded as the best practical environmental option. However, sewage sludge contains heavy metals which accumulates in arable soil layer because they are not quickly leachates but what plants accumulate is very less compared with the contribution carried out. Increasing concentrations of heavy metals in soils may affect their long-term fertility and agricultural productivity.

Outside of nutrients, in sludge are varying amounts of heavy metal which accumulation in the soil, over certain limits, may adversely affect the soil life, plant life, product quality of agricultural food, environment.

The concentration of heavy metals in sewage sludge is limited because of the possibility of transfer in land, through plants, throughout food chain, to the final consumer – human. Heavy metals are present as highly soluble salts or in combination strong related to organic matter present in the sludge. These heavy metals are issued only if the soil is very acid.

Some heavy metals are recognized as micronutrients or dietary elements necessary for plant nutrition. These manifests toxicity only when they are in excessive amounts. Others (cadmium, lead, mercury), in all cases manifest toxic action. Although they are in small amounts in soil, but when they get into food, even in small quantities, heavy metals gradually accumulates in the bodies of animals or humans and sometimes after a few years, after exceeding concentration limits, may give rise to incurable diseases.

The content of heavy metals in sewage sludge is mainly due to industrial wastewater discharged into public sewers. To mitigate these toxic elements is necessary proper pretreatment of these effluents in the industrial enterprises, accompanied by retention of inorganic sludge. The technologies for treatment of this type of effluent shall be established in each case, depending on the metal ions contained.

Another problem with the use of sewage sludge in agriculture is due to their pathogenic potential (Figure 23). These sludges can contain bacteria (Salmonella sp., Shigella sp., Yersinia sp., Campylobacter jejuni, Listeria monocytogenes etc.), (hepatitis A, rotavirus, enteroviruses), protozoan parasites (Cryptosporidium sp., Giardia intestinalis, Entamoeba histolitica), parasitic helminths (Ascaris lumbricoides, Trichus trichiura, Toxicara sp., Taenia sp., etc.) there are fears that some of these microorganisms may reactivate even after some time of sludge processing through composting.

Measures to destroy microorganisms and organisms are following:

- through anaerobic digestion, pathogenic bacteria and helminth eggs are destroyed;
- through pasteurisation of digested sludge at temperature 80 – 90˚C;
- through lime treatment of sludge, before being used in agriculture;

- through sludge composting, when takes place humification and is produced its disinfection.

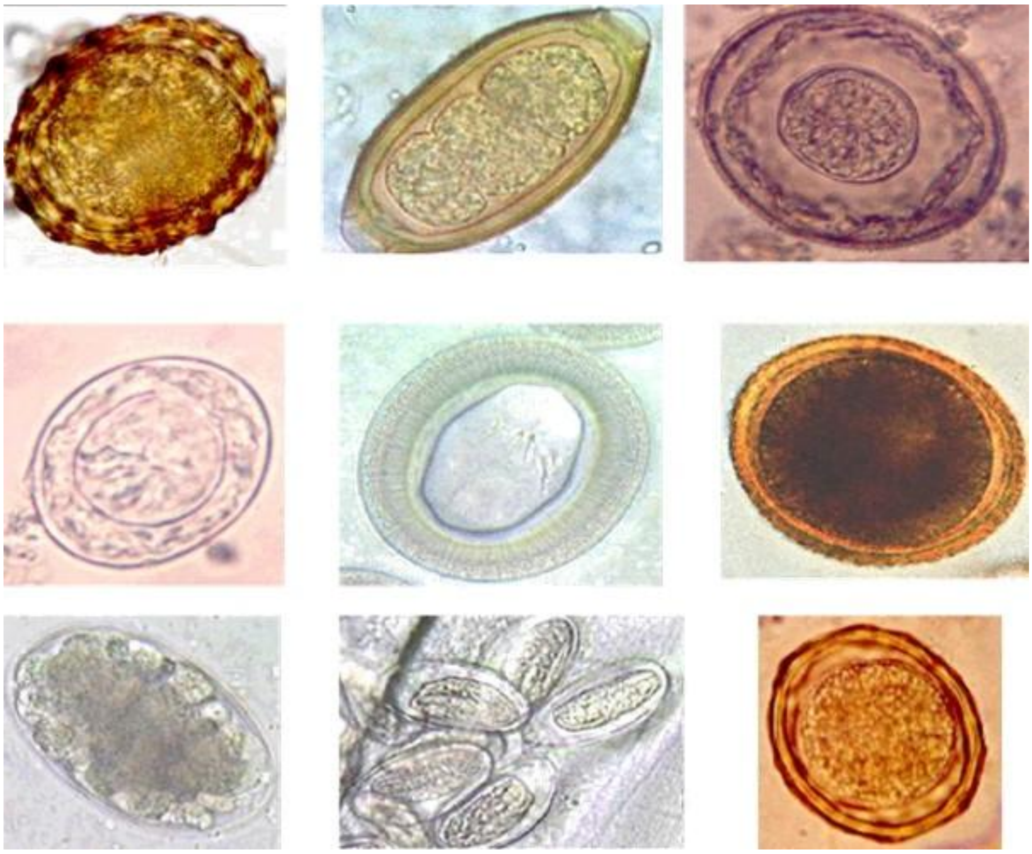


Figure 23. Helminth eggs

6.1.2.2. Characteristics of sludge in forming process at Chisinau Wastewater Treatment Plant

In the literature there is a sufficient amount of information on quality of sludge from urban wastewater treatment, to be used forsoil amelioration of soils, in conditions of of sustainable agriculture.

The composition of sludge mainly dependent on the characteristics of the wastewater, being influenced by treatment processes applied during processing.

Table 4 : Characteristics of sludge samples from Chisinau Wastewater Treatment Plant, formed by dewatering through geotextile bags

Index, measurement unit	Index values			
	Natural humidity of sludge from geotextile bags		Dry matter of sludge from geotextile bags	
	2 months	4 months	2 months	4 months
pH, UNT	5,5	7,8	-	-
Humidity, %	80,2	76,1	-	-
Dry substance, %	19,8	23,9	-	-
Organic substance, %	16,2	20,0	84,3	81,5
Total nitrogen, %	0,62	0,69	3,1	2,6
Total phosphorus, (P_2O_5), %	0,34	0,42	1,7	1,7
Total potassium, (K_2O), %	0,04	0,05	0,22	0,21
(NO_3), mg/100 g	11,7	23,4	58,2	95,5
Pb, mg/kg	65,9	76,1	327,8	310,8
Cd, mg/kg	6,1	7,5	30,5	30,8
Cr, mg/kg	56,1	77,2	279,0	315,3
Ni, mg/kg	16,9	21,1	84,0	86,3
Cu, mg/kg	26,6	28,7	112,3	117,0
Zn, mg/kg	68,7	91,0	341,8	371,3

Table 5: Characteristics of pathogenic microflora for sludge formed in the process of urban wastewater treatment (analyzed samples was performed by Chisinau Municipal Public Health Center)

No.	Determined index	The index value in sludge samples			Maximum admissible level	ND on investigation methods
		1	2	3		
1	E. coli	$<10^3$/kg	$<10^3$/kg	$<10^3$/kg	-	IM no. FT/4022 of 24.12.2004
2	Enterococcus	10^4/kg	10^5/kg	10^7/kg	-	
3	Clostridium perfringens	10^3/kg	10^4/kg	10^5/kg	-	
4	Enterobacteria	în 10 g	în 10 g	în 10 g	-	

	pathogenic, inslusive Salmonella	not detected	s-au depistat Salmonella gr. 07	not detected		
Sample 1 fresh sludhe from geotextile bags – direct from bags; **Sample 2** sludge from storage platform - 0,5 years; **Sample 3** sludge from storage platform - 1 year.						

Table 6: Helminthology indexes of sludge formed at Chisinau Wastewater Treatment Plant

Location of sampling	Total eggs, larvae for 1 kg of sludge, at different depths		
	0 cm	10 cm	30 cm
Sample 1 fresh sludhe from geotextile bags – direct from bags	875	550	250
Sample 2 sludge from storage platform - 0,5 years	800	375	200
Sample 3 sludge from storage platform - 1 year	250	125	75

6.1.2.3. Characteristics of sludge from Chisinau Wastewater Treatment Plant, used for soil amelioration on fields of Experimental Base of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova

Chemical characteristics of sewage sludge used on experimental fields of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova are presented in Table no. 7. Sewage sludge has an average content of organic matter and nutritional elements, and maximum allowable concentrations of heavy metals are within the limits set in Directive 86/278/EEC and Government Decision no. 1157 of 13.10.2008 on approval of the technical Regulation „Soil protection measures into agricultural practices”.

The chemical composition of sewage sludge and physical characteristics vary from one batch of sludge to another, but in all cases heavy metal content is below limit of the concentration.

Table 7: Characteristic of sludge samples from Chisinau Wastewater Treatment Plant, used as soil improver on fields of Experimental Base of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova

No.	Determined index	Measurement unit	The value of index by no. of sample		
			1	2	3
1	pH	UNT	7,3	7,4	7,2
2	Humidity	%	47,1	48,6	51,94
3	Dry substance		52,9	51,4	48,04
4	Organic substance		20,9	13,5	29,4
5	Total nitrogen	mg/100 g	0,675	0,445	22,8
6	P_2O_5		24,0	18,7	26,4
7	K_2O		75,6	55,6	65,8
8	NO_3		23,7	24,8	22,6
9	Pb	mg/kg	75,0	66,0	56,8
10	Cd		6,25	4,55	3,68
11	Cr		405,8	431,3	414,9
12	Ni		79,0	72,5	47,97
13	Cu		299,9	184,9	263,11
14	Zn		503,1	359,6	536,25
15	Hg		not detected	not detected	not detected
16	Helminths	Total no./dm^3	0	0	0

6.1.2.4. Experimental results on evolution of heavy metals in soil fertilized with sewage sludge from Chisinau Wastewater Treatment Plant

The results of chemical analyzes, carried out on average soil samples, at the end of first vegetation cycle, are presented in Table no. 8. The quantity of humus after first year of culture was between 1,45 – 2,10 % at variants carried out on soil treated with sludge, that is more with 0,1-0,3% than in untreated soils.

Total nitrogen content in soil was also influenced by application of urban sludge, the recorded values are between 0,087 – 0,123 mg/100 g at variants with untreated sludge ande 0,14 – 0,18 mg/100g at variants where was applied urban sludge.

Total phosphorus analyzed for soil from experimental variants, had low values in untreated variants, respectively 1,7 – 2,0 mg/100 g, but in variants where was applied sludge, was nouted an increase relatively proportional to applied dose, respectively values from 2,1 to 6,7 mg/100g.

Regarding pH, in untreated variants had values between 7,9 an 8,1 and is essential changing in treated variants.

The content of heavy metals in soil at the end of period intended for studying of urban sludge effect on soil, was within normal limits mentioned in specialized literature.

Table 8: Agrochemical characteristic of soil from experimental lot under sunflower culture (filed no. 1)/soybean

No.	Determined index	Measurement unit	Value of index			
			Sunflower culture (filed no. 1)			Soybean culture
			experim. lot 50 t/ha	experim. lot 100 t/ha	experim. lot 150 t/ha	experim. lot 50 t/ha
1.	pH	UNT	8,25	7,8	7,35	7,95
2.	Humus	%	1,55	1,45	2,10	1,9
3.	Total nitrogen	mg/100 g	0,18	0,14	0,18	0,14
4.	P_2O_5		2,1	2,9	6,7	4,3
5.	K_2O		14,8	15,8	23,2	26,2
6.	Pb	mg/kg	13,8	14,6	20,4	12,9
7.	Cd		0,60	0,8	0,60	0,7
8.	Cr		77,0	42,0	67,0	71,0
9.	Ni		3,2	2,8	8,7	5,0
10.	Cu		16,0	14,0	14,3	17,0
11.	Zn		12,0	10,0	7,0	15,0

6.1.2.5. Experimental results on evolution of heavy metals in plants cultivated on soil fertilized with sewage sludge from Chisinau Wastewater Treatment Plant

While the chemical analyzes carried out on samples of vegetative organs (strains, roots), first of all have purpose of revealing the absorption capacity of the mineral elements by the plant and their presence in necessary quantitiesto ensure the physiological functions of plant's, those carried out on samples of seedsserve to alert us of their quality and the size of sludge doses used as fertilizer. Chemical analyzes carried out on soya (strains, roots) and on grains have revealed the following:

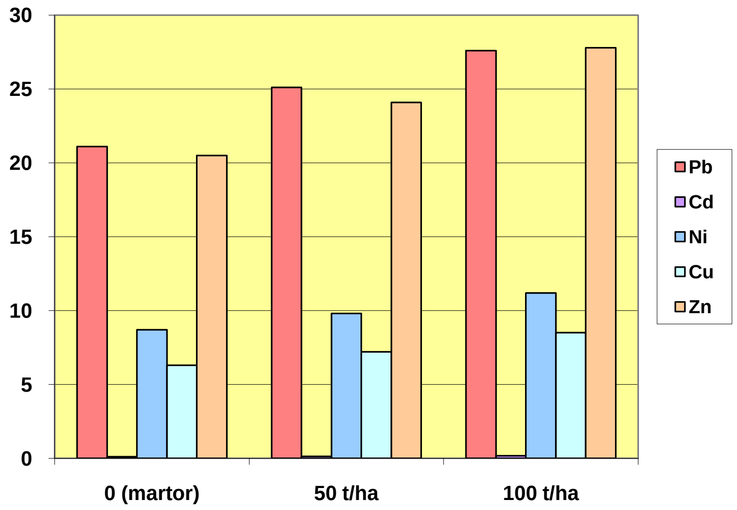
- soya strains had a lead content slightly above the normal limits in plant but under phototoxic level in all experimental variants;
- roots of soya plant had a lead content, also slightly higher than the normal limits but under phototoxic level, in variants fertilized with sewage sludge compost and in unfertilized;
- soya grains had a lead content in normal limits in all variants;
- the content in cadmium in soya strains recorded values under normal limits;
- the content in cadmium in soya roots were higher than in strains, but under toxicity threshold limits;
- in soya grains was detected the lowest level of cadmium (0,11 mg/kg) in treated variant with 50 t/ha and 0,14 mg/kg intreated variant with 100 t/ha of sludge;
- content of Ni, Cu an Zn in strains, roots and in grains was well below the toxicity in all oragans of soya plant, regardless of the applied dose.

However, it is necessary to mention that with increasing doses of fertilizer, it is oberved a slight tendency to accumulate heavy metals in all organs of plants, which implies a strict control of the quantities of applied sludge (table no. 9).

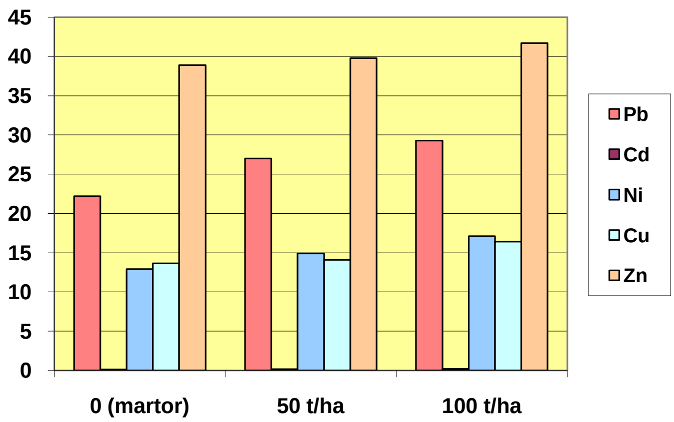
Table 9: The influence of different sludge doses from Chisinau Wastewater Treatment Plant on content of heavy metals in soybean strain, roots and grains

Sludge dose	Pb	Cd	Ni	Cu	Zn
Soybean strain					
0 (witness)	24,1	0,10	8,7	6,30	20,5
50 t/ha	25,1	0,12	9,8	7,20	24,1
100 t/ha	27,6	0,17	11,2	8,50	27,8
MAC	3 – 15	1,0	30,0	15 - 20	200,0

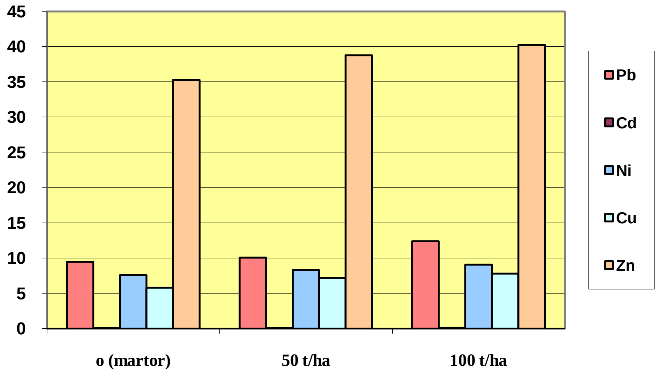
Soybean root					
0 (witness)	22,2	0,12	12,9	13,65	38,9
50 t/ha	27,0	0,17	14,9	14,10	39,8
100 t/ha	29,3	0,21	17,1	16,4	41,7
MAC	3 – 15	1,0	30,0	15 - 20	200,0
Soybean grain					
0 (witness)	9,5	0,09	7,6	5,8	35,3
50 t/ha	10,1	0,11	8,3	7,2	38,8
100 t/ha	12,4	0,14	9,1	7,8	40,3
MAC	3 - 15	1,0	30,0	15 - 20	200,0



a) soybean strain



b) soybean root



c) soybean grain

Figure 24. Dynamics of heavy metals in soybean strains, roots and grains

6.1.2.6. Research of efficiency of sewage sludge from Chisinau Wastewater Treatment Plant on productivity of agricultural plants

Figure 25. Research works on sludge action on harvest

For performing the study on use of dewatered sludge from Chisinau Wastewater Treatment Plant as organic fertilizer, and also carrying out research works of action on the harvest (fig. 25), weeding degree and countermeasures, on fields of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova were transported 11 750 t of fertilizer from Chisinau Wastewater Treatment Plant, in 2 stages.

First trance – 5 500 t:

1. Experimental field with sunflower – 2 250 t:

   3 ha x 250 t/ha = 750 t

   3 ha x 200 t/ha = 600 t

   3 ha x 150 t/ha = 450 t

   3 ha x 100 t/ha = 300 t

   3 ha x 50 t/ha = 150 t

2. Multiplication fields – 3 250 t:

   Sunflower 6 ha x 50 t/ha = 380 t

   Sunflower 20 ha x 100 t/ha = 2 000 t

   Soybean 5 ha x 50 t/ha = 250 t

   Soybean 7 ha x 100 t/ha = 700 t

Second trance – 6 250 t:

Barley 18 ha x 150 t/ha = 2 700 t

Sunflower 18 ha x 150 t/ha = 2 700 t

Autumn wheat 2 ha x 150 t/ha = 300 t

Soybean 8 ha x 50 t/ha = 400 t.

Thus, rational use of fertilizer ensure increase of crop productivity (tab. 10) with 20 – 46%. Incorporation into the soil of optimal doses, leads to the formation of additional harvest for sunflower with 211 – 461 kg, soya 160 – 490 kg, barley 146 – 266 kg/ha in comparison with witness.

Table 10: The harvest and increase of production of different cultures, in the result of using of sewage sludge as fertilizer

Sludge dosage, t/ha	Culture	Harvest, kg/ha	In addition to the witness kg/ha
Control	Sunflower	1069	-
	Soybean	1126	-
	Barley	2164	-
50	Sunflower	1290	+211
	Soybean	1286	+160
	Barley	2310	+146
100	Sunflower	1360	+301
	Soybean	1616	+490
	Barley	2430	+266
150	Sunflower	1530	+461
200	Sunflower	1450	+381
250	Sunflower	1380	+311

6.2. Sludge composting

Sludge composting (Figure 26) is an alternative to the direct use of sludge in agriculture. This is process very appreciated and used, because he allows, among other, a very good hygienisation of sludge, as well as co-composting of waste (for example: composting of sludge mixed with urban domestic waste containing predominant organic).

Figure 26. Composting of sewage sludge

Composting is the biological conversion process of solid organic matter in the product usable as fertilizer, a substrate for biogas or for mushrooms production. Compost can be regarded as a organic hygienic product, free of undesirable characteristics, with broad applicability in agriculture and horticulture, as well as and a relief in relation to many environmental problems.

Composting is the sum of a series of complex metabolic processes and transformations which is caused by the activity of a mixture of microorganisms population.

Composting can be defined as a controlled biological process of conversion and recovery of waste organic materials (by-products of biomass, organic waste from biological origin) in a stabilized product, hygienic, like earth, rich in humic compounds.

Composting is also a ecotechnology because it allows the return of organic matter in soil and so reintegration in major vital ecological cycles of our planet (Figure 27).

Compost can be produced starting from pressed sludge and green waste and wood, sewage sludge (21%) and municipal waste (62%). The sawdust offers ideal conditions as bulking agents. Sawdust prevents the formation of massive material, thus improving air circulation and porosity in the compost heap.

Also, sawdust contributes to numerous macronutrients and micronutrients of compost mixture. All this requires careful monitoring during the composting process and taking appropriate action.

Figure 27. Composting process

Co-composting of sewage sludge that is dewatered and anaerobically stabilized, solid residues with organic fraction of municipal solid waste, make to increase the content of humic substances in the final product. Dewatered sewage sludge, anaerobically stabilized, solid residues are supple and lends itself to treatment by composting due to report lower C/N. The content organic matter in the sewage sludge is small (45,10% and 24,10%, respectively), compared to the organic fraction of municipal solid waste. For this reason, is necessary co-composting of organic fraction of municipal solid waste, which have high contents of organic matter, humic substances, report C/N, lignin and cellulose compared to sewage sludge.

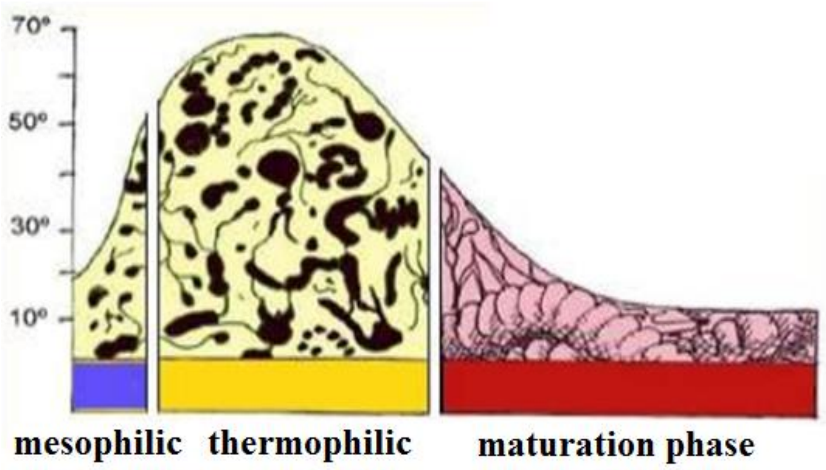


Figure 28. Stages of composting process

Thus, were identified three main phases of the composting process (Figure 28):

➢ phase 1, mesophile fermentation stage, which is characterized by the growth of bacteria and temperatures between 25 and 40 ºC;

➢ phase 2, thermophilic stage in which are presented bacteria, mushrooms and actinomycetes (the first level of consumer) at the temperature 50 – 60 ºC, decomposing cellulose, lignin and other resistant materials; the upper limit of the thermophilic stage may be at 70 ºC and it is necessary to maintain the high temperature for at least one day, to ensure destruction of pathogens and contaminants;

➢ phase 3, is the stage of maturation, where temperatures are stabilizing and continues some fermentations, converting degraded material in humus by condensation and polymerization reactions; the last objective is to produce a material that is stable and can be judged on the C:N ratio; well composted materials have reduced ratio of C:N; for ex. ratio C:N may decrease from 30 at the beginning of composting process to 15 in mature compost.

During active composting, aerobic decomposition generates carbon dioxide and vapor of water. Active anaerobic decomposition generates carbon dioxide, methane and other fermentation products that create odors, reduced pH in composting heaps and inhibits the growth of plants. Many factors affect the generation of odors: the amount of oxygen in heap, characteristics of the materials subjected to composting, the initial pH of the mixture and materials used as additives.

Even if there is a good supply of oxygen (obtained by diffusion, reshuffle or forced aeration) in composting heap still remain some smaller or higher bags, in which the process is carried out under anaerobic conditions. The products in these anaerobic bags will decompose when they will reach to aerobic conditions in composting heap (Figure 29).

Figure 29. Composting heap

Necessary microbial organisms for composting appear naturally in many organic material. However, there are numerous owners of salable products to activate or use as composting starter. The addition of bacterial cultures or other products refers to inoculation or sowing. Although the use of stimulators can boost composting (in particular the by-products which are relatively sterile), most manufacturers of compost considers them rarely necessary.

However, in the world are practiced at least 5 composting methods:

A. passive composting (opened heaps);

B. composting on the beds, in rows or heaps, using charger for returning, mixing and handling;

C. composting at the beds using special equipment for heap reshuffle;

D. static heap systems that are aerated using perforated pipes;

E. systems for composting in container.

The first three methods commonly are practiced outdoors and the last two indoors to have a better humidity control, treatment and capture of odors.

A) Passive composting in opened bulk (figure 30) involves the formation of heap by organic material and leaving it undisturbed until the materials are decomposed into stabilized products. These small heaps have the advantage of natural air movement. Due to active fermentation heap is heated inside, warm air rises and loses at the upper surface of heap, is replaced by cold air that enters through the bottom of heap and along the sides, thus refreshing air into the heap. Depending on the size of the heap, air currents can refresh faster or slower air from heap activating fermentation process.

Figure 30. Opened composting

The disadvantage of passive composting or undisturbed, is that unmanaged heap gets too wet, too dry, too compacted, and can quickly become anaerobic and very fragrant.

B) Composting on the beds, in rows or heaps (figure 31) is the most common form of composting. For an active management of the process, rows and heaps are reshuffled using a special machine which avoids compacting of the heap, improves air exchange brings to the surface of heap material from inside and introduce in heap material from the surface of of the heap.

Figure 31. Composting on the beds, in rows or heaps

In this way can be destroyed by composting, weed seeds, pathogens and larvae, they reach in middle of the heap where the temperature is very high. Turning and mixing again during the reshuffles of materials that are subjected to composting, they fragment into smaller particles and increases their biologically contact active surface. The excess of reshuffle may reduce the porosity of the heap if the particle size becomes too small. The size of the heap (of the string) is given of characteristics of the equipment that performs reshuffle of the heap. It is preferred that the composting platform is surrounded by a ditch to collect leakages. The collected liquid can be used for wetting of heap at the reshuffle if this is necessary or can be applied to agricultural land as fertilizer liquid.

C) Composting on the platform using specialized reshuffle equipment is practiced in large units producing of compost. Is identical mode of organization to the method B – composting on the beds, in rows or heaps, but is obligatory the presence of special equipment for reshuffle.

D) Aerated static heap system with perforated pipes – can develop in the open or closed spaces. At the heap basis are incorporated perforated pipes for aeration. The hot gases inside the heap rises and cold air enters through pipes inside the the heap. Can be practiced and forced aeration, using air blower in pipes at the bottom of the heap, which makes air circulation to be more faster.

Forcing aeration system allows growth of the heap and a better control of the composting process. The arrangements of negative pressure (inside of perforated pipes) allow direct air extraction through biological filters if odors are a problem. Aerated static heaps are based on wood chips chopped straw or other porous materials. The porous material at the base incorporates perforated aeration pipes. Selecting and initial mixture of raw materials, that are subjected to composting are essential, because it must have a good structure to maintain porosity for the entire period of composting. This general requirement is ensured by the use of an agent for maintaining the density, such as straw or wood chips. Original height of aerated static heap is 1,5 ÷ 2,5 m. In winter biggest heaps helps to maintain the heat. A layer of finished compost cover the compost heap. The length of aerated static heaps is limited by the air distribution through aeration pipes. For aerated static heaps mixing of material deposited in heap, is essential because heap is formed once. The mixing of the heap is made using a front loader type Fadroma by mixing several times in another heap and then submitting in final heap of mixed materials. It is recommended that mixing and forming of the heap to make on concrete surface.

E) systems for composting in container involves closing the active composting material in a container, building, etc. Container system has the most aggressive management and generally with the largest capital investment, but provide the best control of the composting process. Most methods in container involve a variety of systems for forced aeration and techniques for automatic winding, leading to intensification of composting. Some composting systems in containers, include no return composting materials.

Regardless of practiced method of composting, the ability of the composting heap to heat and to maintain a high temperature depends on 7 factors:

- physical and biological composition of materials subjected to composting;
- accessibility of of nutrients, including microorganisms that produce carbon for composting;
- the level of humidity in materials subjected to composting;
- the heap structure (particle size, texture and bulk density);
- aeration rate in heap or in row;
- the size of composting heap and ambient conditions (temperature, wind, humidity, etc.).

Thus, composting is economically relevant once the final composted product is recognized as a recyclable product that can be certified and sold at the price that allows to cover a part of CAPEX (capital expense) and OPEX (operating expense) relatively high associated with this process.

These conditions are not satisfied in the local context in Republic of Moldova and seems early to investigate the feasibility of this option because even agricultural use of of sludge is not yet guaranteed and practiced in Republic of Moldova.

6.3. Incineration

If the quality of sludge from the wastewater treatment plant is not good for use in agriculture, Wastewater Treatment Plant should find another modalities for sludge elimination. All types of energetic valorification, like: co-incineration in cement factories, fuel combustion or incineration in fluidized bed requires a sufficient sludge caloric power.

This means that the drying process should take place in a separate installation or in a combination with an incinerator. Thus, for incineration is recommended preliminary reduction of humidity of raw sludge and avoidance of aerobic stabilization or aerobic digestion, that diminishes caloric power of material for incineration.

Also, the lack of an adequate legal framework on waste incineration in Republic of Moldova (comparable with European legislation stipulating waste incineration as mentioned in Directive 2000/76/ EC, which refers to incineration plants and co-incineration and sets limit values for emissions into air and for discharges of wastewater from treatment of residual gases) endanger the acceptance of this technical solution by the municipality. The risk can be reduced, if in Republic of Moldova will be adopted regulations in accordance with EU norms. Also, there may be a significant public opposition.

Incineration is a thermal process that burns the sludge. Today, the most commonly used technology is the ,,fluidized bed furnace” (FBF). FBF are based on the principle of fluidizing a bed of sand with hot air heated from the bottom. This technology results in the total combustion of the sludge at a temperature between 850 – 900 °C in the span of only a few seconds of retention time.

A fluidized bed incinerator (figure 32) is composed of a four - part reactor:

✓ a fluidizing air intake area, the wind box (1). Fluidizing air, which serves as combustion air, goes into the wind box, either at room temperature (cold wind box) or pre-heated to about 600°C (hot wind box). Most fluidized bed sludge incinerators are designed with hot wind boxes;

✓ an air distribution system (2);

✓ a sand bed fluidized at around 750°C, into which the sludge is injected, with orwithout support fuel (3);

✓ a combustion chamber on the upper level (4).

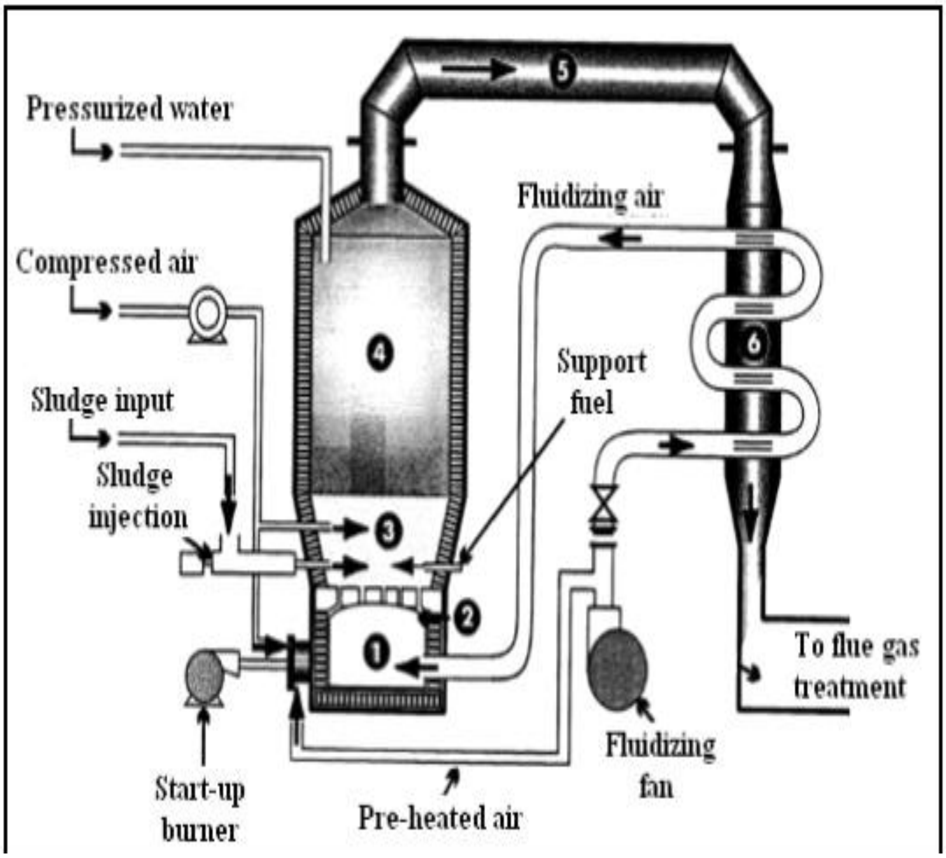


Figure 32. Scheme of a fluidized bed furnace

Fluidized bed incinerators are not very flexible when it comes to variations in sludge inlet flow rate, at a constant heat balance (flexibility of about 15% with respect to the nominal load). On the other hand, it can handle frequent stops and starts.

The heat required to evaporate the water and bring the combustion gases to the desired temperature is brought by:

- the oxidation of the organic content in the sludge;
- the re-heating of the combustion air to about 600°C (hot wind box);
- the use of support fuel, if needed (natural gas, fuel oil).

The sludge is completely destroyed by combustion, leaving the following three byproducts:

- ash or non-hazardous residues: composed of the mineral content of the sludge, which is recovered at the incinerator outlet. The quantity of ash produced depends on the sludge's initial mineral content. The ash is usually removed to a landfill center or could be recycled for use in cement production or road construction.

- exhaust gas residue or hazardous residue: composed of the pollutants contained in the sludge, which have been trapped during the treatment of combustion gas, mainly heavy metals and acids. The quantity is estimated at 20-40 kg/tDS for dry treatment and much less for wet treatment. The residue is removed to a specific sanitary landfill.
- combustion gases: dispersed into the atmosphere after energy recovery (at the cooling stage) and treatment. Thermal energy is recovered from the exhaust gas.

The residues of sludge incineration and flue gas treatment consists in ashes that can be further utilized as mineral material in cement factory or concrete manufacturing process or used as building material for road construction. Ultimately, ashes can also be landfilled.

The major interest of thermal oxidation is the ability to produce energy thanks to the sludge energy potential. A rough estimate of the sludge production gives a value in the range of 40 to 80 g/L of dry solid per day and per capita, containing 2/3 of organics or more. Consequently, the energy potential on a dry fuel basis achieves 10 to 15 W per capita.

A huge amount of energy is recoverable through thermal oxidation processes. Practically, this energy, at high enthalpy level, is recovered on the economizer. The recovering fluid can be pressurized water, steam or diathermy oil (or air if energy is wasted). The heat can be directly used as thermal fluid for building heating, process requirements, or preheating of sludge prior to dewatering/pre-drying to improve the performances.

The best way to value the energy potential is definitely a cogeneration facility through the generation of high pressure steam and turbine with steam extraction (Rankine Cycle). In such a way, up to 35% of the sludge potential energy can be recovered as heat and 10% as electricity. The implementation of a cogeneration facility is therefore very beneficial for the environment since it reduces the fossil energy utilization and the associated emission of greenhouse gases.

CONCLUSIONS

The main shaft of environmental policies is to ensure a clean environmentfor public health, but the problem-key of sustainable development, is the reconciliation between two human aspirations: the necessity of economic and social development, but also protection and improving of the environmental situation, as the only way for the welfare of both the present generationand those future.

The process of wastewater treatment lead to retention and formation of large quantities of sludge that encompassing pollutants and inert substances.

The sludge treatment processes are very different and therefore cannot establish universal technology, but for each wastewater treatment plant should be studied properties of the sludge subjected to processing.

At the basis of all sludge treatment processes are two distinct processes and namely sludge stabilization through sludge digestion and dewatering. Between these two main processesmay occur various variants or combinations ofprocesses, the application of which is differentiated depending on local conditions, quantity and quality of sludge, availability of land for the installations, dewatering and storage platforms.

Management of sludge that results from processing of urban wastewater is one of the biggest problems in human collectivity, where production of sludge is an ongoing processwhich requires finding of flexible solutions and safe evacuation and recovery.

Latterly, in the the conditions of awareness of the benefits of organic fertilizersin the organic farming, using of sludge that results from urban wastewater treatment is an non-negligiblealternative, in conditions when environmnetal pollutionby this is almost eliminated. Considered to be true chemical bombsdue to the heavy metal content, sludge valorification can be done on the various directions, but it seems that at the current juncture, the most efficient way is to be used as a soil ameliorant, in conditions when use of mineral fertilizers and of livestock manure is increasingly limited, to avoid the occurrence of the pollution caused mainly by nitrates.

Also, scientific literature abounds with data related to the use of sludge from urban wastewater in agriculture, on different types of soil from different parts of the world and different cultures, as ecological alternative to the use of mineral fertilizers and of livestock manure, in conditions when this waste could be eliminated without negative effects on environment.

From the data presented in this work results that sludge from urban wastewater treatment could be used for soil amelioration, in order to improve the qualitative characteristics of the fertility of the soil, and also for raising the quantity and quality of cereal cropswhich may be obtained on these soils.

Thus, the experiments performed during the years 2014 – 2015 on fields of experimental base of Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova, demonstrated efficacy of using of dewatered sludge from Chisinau Wastewater Treatment Plant as fertilizer under different agricultural cultures.

Obtained results demonstrate that the largest increase of the harvest was obtained for the sunflower crop, being 15 – 43 % compared to control. Significant increases were obtained and for barley culture – 12.3% in variant in which were administered 100 t/ha of sludge. Soya culture achieved an increase of almost ten percent in both variants, being less receptive to increasing of sludge dose.

Also, the research carried out worldwide indicates the possibility of using in agriculture of sludge from urban wastewater treatment for the purpose of soil amelioration, benefits obtained being evidenced by reducing cropscosts, improving of soil fertility and of nutritional conditions for plants, generating higher qualitatively and quantitativelyharvests.

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ASSESSMENT OF TASKS PERFORMED AND THEIR RELATIONSHIPS WITH THE KNOWLEDGE SKILLS ACQUIRED IN THE DEGREE

The main objective of **Double Degree Programme on Master in Environmental Science, Technology and Management** (University of A Coruna)/**Master in Management of Sanitary Engineering Facilities and Environmental Protection** (Technical University of Moldova), is to provide a quality education program, able to prepare engineers specialized in environmental protection, having an appropriate level of qualification to exercise the profession and to insert in the labor market.

Also, **RETHINKe project in the field of Environmental Science** has the following basic objectives:

- to promote the reform and modernisation of higher education in Moldova;
- to enhace the quality and relevance of higher education in Moldova;
- to build up the capacity of higher education institutions in Moldova and Spain, in particular for international cooperation and for a permanent modernisation process, and to assist them in opening themselves up to society at large, the world of work and the wider world;
- to foster the reciprocal development of human resources in both institutions;
- to enhance networking among University of A Coruna and Technical University of Moldova;
- to enhance mutual understanding between peoples and cultures af Spain and Moldova.

Environmental studies cover a wide interdisciplinary area, which investigates how the natural world works and how humans interact with it. This area of study approaches present environmental issues such as pollution, global climate change and depletion of natural resources. Environmental sciences try to find sustainable ways to maintain or improve the integrity of the natural environment.

Thus, as a result of rapidly increasing population, urbanization and industrialization, wastewater production and sewage sludge generation have increased manifold. Due to high cost of mineral fertilizers and escalating trends in their prices, there is an increasing trend of using sewage sludge in agriculture, especially under intensive cropping. Sewage sludge is very important biological organic fertilizer/soil conditioner for sustainable agriculture.

Therefore, use of sewage sludge in agriculture will be appropriate and beneficial, if applied according to appropriate guidelines to minimize environmental and ecological damage and maximize potential benefits for sustained agricultural productivity. However, sewage sludge prior to use in agriculture must be subjected to evaluation tests for determining the basic physicochemical properties, content of pollutants or pathogenic bacteria, and also ecotoxicological properties in order to avoid the risk of potential threats for the environment and for human health.

In conclusion, the present work describes the sewage sludge treatment methods (based on real example – Chisinau Wastewater Treatment Plant) and pays special attention to use of sewage sludge from this Treatment Plant in agriculture as organic fertilizer.

Thus, the high theoretical level achieved in these Double Degree Programme, the close relationship between theoretical and practical concept, using of obtained data after research, multilateral and depth analysis of such data and so on, have helped me in elaboration of Master's thesis.