*Journal of Engineering Science* *Vol. XXX, no. 1 (2023), pp. 128 - 139*
*Fascicle* *Architecture, Civil and Environmental Engineering* *ISSN 2587-3474*
*Topic* *Environmental Engineering* *eISSN 2587-3482*

**https://doi.org/10.52326/jes.utm.2023.30(1).11**
**UDC 628(478)**

# A NEW CONCEPT REGARDING THE SELECTION OF SEWERAGE SYSTEMS AND NATURAL TREATMENT OF MUNICIPAL WASTEWATERS

Victor Covaliov[1], ORCID: 0000-0002-0941-3050,
Dumitru Ungureanu[2], ORCID: 0009-0007-6087-9132,
Gheorghe Duca[3], ORCID: 0000-0001-7265-6293,
Olga Covaliova[3]*, ORCID: 0000-0002-0387-3195,
Lidia Romanciuc[3], ORCID: 0000-0002-4555-1194

[1]*Moldova State University, Institute of Research and Innovation, 60 Mateevici Str., Chisinau, Republic of Moldova*
[2]*Technical University of Moldova, Stefan cel Mare si Sfant Blvd., Chisinau, Republic of Moldova*
[3]*Moldova State University, Institute of Chemistry, 3 Academiei Str., Chisinau, Republic of Moldova*
*Corresponding author: Olga Covaliova: *covaleva.olga@yahoo.com*

Received: 01. 27. 2023
Accepted: 03. 22. 2023

**Abstract.** The article contains a review of methods and procedures of the municipal wastewater treatment, with the discussion of their specifics. A new concept is proposed related to the selection of municipal sewerage and wastewater treatment systems, considering the local/decentralized, semicentralized or centralized systems, especially those suitable to rural and suburban localities, in dependence on the advantages and disadvantages of these systems and local specifics. The concept of phytofilters is proposed for the biological treatment of wastewater in small towns. This technology is simple, inexpensive and requires relatively little maintenance. Biological ponds in the Republic of Moldova have proven to be very suitable for advanced wastewater treatment, being a cheap and natural purification system with a good potential for implementation. When choosing a sewer system, priority must be given to its functionality and practical considerations.

**Keywords:** *sewerage systems, wastewater treatment, biological ponds, phytofilters, suspended microflora, fixed microflora.*

**Rezumat.** Articolul conține o trecere în revistă a metodelor și procedeelor de tratare a apelor uzate municipale, cu analiza specificului acestora. Se propune un nou concept legat de selectare a sistemelor municipale de canalizare si tratare a apelor uzate, având in vedere sistemele locale/descentralizate, semi-centralizate sau centralizate, in special cele adecvate localităților rurale si suburbane, in funcție de avantajele si dezavantajele acestor sisteme si de specificul local. Conceptul de fitofiltre este propus pentru tratarea biologică a apelor uzate din localitățile mici. Această tehnologie este simplă, relativ ieftină și necesită o întreținere relativ nesemnificativă. Iazurile biologice din Republica Moldova s-au dovedit a fi foarte potrivite pentru tratarea avansată a apelor uzate, fiind un sistem de epurare ieftin și natural, cu un bun potențial de implementare. Pentru alegerea unui sistem de canalizare, prioritate trebuie acordată funcționalității acestuia și considerațiilor practice.

**Cuvinte cheie:** *sisteme de canalizare, epurare a apelor uzate, iazuri biologice, fitofiltre, microfloră în suspensie, microfloră fixă.*

## 1. Introduction

Nowadays, from the point of view of social development, water supply and sanitation systems which have been applied mainly in the rural area and will be further developed, gain the special importance considering the association of the Republic of Moldova to the EU [1]. This fact is one of the beneficial consequences of association, and, therefore, there is still time to pay attention to one of the most important aspects – sewerage and waste waters treatment. First of all, the attention should be paid to the domestic wastewaters resulted from water using in sanitary and household scopes.

In addition to the high quality potable water, used by the people in houses or apartments for drinking and food preparation, the domestic water is also used in the toilets, forming the so-called *brown water* with the contents in urine and feces, evacuated with the closets flash water, and the so-called *grey water* used for corporal hygiene, kitchens and washing machines. In dependence on the toilet type, a person consumes from 10 to 25 thousand litres of water per year (brown wastewater), whereas in dependence on the condition of other sanitary objects and water savings in the households, from 25 to 100 thousands litres of waste water per person are formed annually.

In a settlement may be functioning the economic entities as well, which may be sources of the industrial waste waters resulted from the technological processes. In dependence on their character, different quantities of water are consumed and evacuated. One can imagine the situation when the waste waters formed in the significant amounts would not be collected and evacuated in the sewage system and further discharged into the different receiving bodies, most often the surface waters, without any treatment.

Therefore, while designing and constructing the water supply systems for the people, the collection, evacuation, treatment and eventually, reuse of the waste waters and sludge treatment should be obligatory envisaged. There are many relevant technical approaches which, however, require both the different investments and the operation costs [2].

## 2. Sewerage systems

In many countries, including the Republic of Moldova, centralized management of waste waters is one of the most common solutions. This imply the collection and evacuation of wastewaters through the centralized sewerage system, up to the central treatment station, where the waste waters and the sludge are treated and depolluted in the controlled conditions (Figure 1).

**Figure 1.** Reservoir from which the water treated at the Orhei treatment plant is discharged into the Raut river [3].

The advantages of this concept imply the lower investment and operation costs for the large treatment plant, as compared to the several smaller treatment plants, considering the more efficient control of both the treated water and sludge quality, and plant operation processes. However, this approach is not universal, especially in case of the less populated regions.

The ratio between the costs and advantages of centralized systems can be less favorable when the big and long-term expenses for the construction and maintenance of sewerage system are taken into account. Provided the sewerage system is not properly maintained, the leaks can appear which may cause the soil and underground waters pollution. The centralized sewerage systems, as a rule, need many pumping stations which must be operated and maintained properly. In addition, the centralized treatment plants reduce the possibility of the waste waters, nutrition substances and sludge reuse, because of the pollution with harmful substances such as chemicals, heavy metals and pathogenic microorganisms, especially in the combined sewerage system where the industrial waste waters are collected as well.

In this situation, the selection of a sustainable public sewerage system is not easy univocal, especially due to the fact that there are decentralized (local), semicentralized (with many treatment plants) and combined (local and centralized) systems available. In the last years the more and more attention is paid to the modern decentralized or semicentralized concepts of local management of waste water, which are already applied in many countries, especially in the rural and suburban zones.

**3. New concepts of the waste waters sewerage and treatment**

During the las 20 years it became obvious that the existing centralized systems for the waste waters treatment have a series of disadvantages. They often do not meet the conditions of durability.

The durability implies the following 5 aspects:

1) *Sanitation and hygiene*: includes the risk of exposure to pathogens and harmful substances, which can affect the public health at all the stages of sewerage system, starting from the toilets, the collection, evacuation, transportation and treatment system, up to the reuse or discharge points into the transmitters/receivers and downstream settlements.

2) *Natural environment and resources*: involve the energy, water and other natural resources necessary to construct, operate and maintain the system, as well as their eventual emissions in the environment resulted from their usage; it also implies their recycling and reuse leve and their effects (such as nutrients and organic substances reuse in agriculture), protection of other fossil / non-renewable sources through the production of renewable energy (such as biogas).

3) *Technology and exploitation*: involve the functionality and easiness with which the entire system, including the wastewater collection, transportation, treatment, sludge treatment, reuse and/or storage, can be constructed, exploited and controlled by the communities and/or technical teams of the utilities' suppliers. In addition, the system resistance, vulnerability with regard to the power outages, water shortage, floods, as well as the flexibility and adaptation of technical components to the existent infrastructure and demographic and socio-economic evolution are the important aspects that need to be evaluated.

4) *Financial and economic aspects*: they are related to the ability of households and communities to pay for the sewerage, including for the construction, operation exploitation, maintenance and necessary reinvestments for the system.

5) *Socio-cultural and institutional aspects*: the criteria belonging to this category evaluate the socio-cultural acceptability, how appropriate and how convenient is the system, its impact on human dignity, conformity with the legislative framework, as well as with the stable and efficient institutional framework.

Even there are wastewater treatment systems already known and the indisputable improvements in the public health and natural environment, the quality of many surface and underground waters remains to be affected by the nutrients, microorganisms and harmful substances resulted from the discharged and treated waste waters.

The need for the nutrients recovery from the waste waters, especially phosphorus – a non-renewable disappearing source, is highlighted by the need of the new concepts that would allow the safe use of nutrients. The management of the centralized sewerage systems and waste water treatment plants is not a right solution for adapting to climate changes, because it requires a lot of energy and does not include the local water circuit. High investment and operation costs, due to the related conditions, obligations and inflexibility, make the centralized systems inadmissibly costly and inefficient.

The conclusion can be made that the sewerage systems should be modified in such a way that they would allow decentralizing, including at the level of households or the group of households. Water circuit must be closed up locally, and the nutrients coming from the households must be available for the reuse in agriculture.

Fundamental principles of the new concepts regarding the canalization and waste water treatment are as follows: (a) on-site waste water treatment; (b) water and nutrients recycling/reuse and (c) decentralization.

To be mentioned that the trend towards the dry sanitation makes part of the new concepts. Specifically, the modern toilets have been elaborated for the rural zones and installed for the compost and separate evacuation of urine. Certain practical examples demonstrate that the dry sanitation combined with the simple filtration of grey waters is an accessible solution from the economic point of view and technically secure for the zones without the secure water supply.

The other trend is the biogas and organic fertilizer collection from toilets, according to the sanitary concepts for urban zones. Domestic wastewaters (from their toilets, grey water, stormwaters) are separated on-site. Vacuum toilets only discharge 5 litres of the domestic wastewater per capita and per day, therefore, the domestic water consumption for potable scopes is very low - below 80 L/pers.·day [4]. The grey waters are treated with filters planted with reed or in the constructed wetlands and are infiltrated locally into the soil, as well as the stormwaters, especially rainwaters [5].

These concepts involve the collection, evacuation, treatment and discharge / reuse of the wastewaters, storage, treatment and using of the sludge from small communities (from the households to the parts of localities) integrated in the locality/village/town development projects. Such systems involve the numerous small-scale wastewater purification equipment, designed and manufactured locally.

The decentralized systems maintain a variety of pollution sources, having both the liquid phase and solid fraction, thus reducing the wastewater collection and disposal network and, respectively, offering a high degree of flexibility allowing to modify the design and the way of the sewage system operation, according to different local conditions and scenarios.

The decentralized and semi-centralized systems offer the following advantages: (a) low investment, operation and maintenance costs for the sewage system with the lower length network; (b) better protection of water sources, with less damage in case of deflections (risk minimization); (c) offer the solutions corresponding to the individual pollution level; (d) are flexible (allow extension) and adaptable to the changes in conditions, population, tourism, industry; (e) permit taking the decisions in dependence on the real needs of sensible environmental zones, they can be implemented when needed; (f) they can be harmoniously framed into the landscape; (g) the treated water and nitrition substances (N and P) can be reused easily.

The main disadvantages of decentralized or semi-centralized wastewater management are as follows: (a) potentially lower wastewater treatment efficiency (especially for the nutrients N and P); (b) need for the training and correct using; (c) the presence of qualified personnel for operation and management is necessary; (d) monitoring can be insufficient; (e) legislation and institutional environment could become an obstacle.

These factors must be considered when selecting the sewage and wastewater treatment system.

## 4. Wastewater treatment technologies

The technology applied for the wastewater treatment is relatively independent of the collection and disposal system for the localities with up to 10 thousand population connected to sewage system. Although any intensive and extensive technology is applicable both locally and on the larger, centralized scale, the technologies have the different advantages and disadvantages. The intensive biological processes are the most highly developed and broadly used technologies on the level of domestic and communal/municipal wastewaters treatment plants [6]. The principle consists in exploiting on a small space the intensified natural biodegradation of the organic pollutants along with the elimination of nutrients (N and P) [7].

The most developed and widely implemented technology is the system with active sludge (with the suspended microflora in the form of very fragile flakes) with mainly pneumatic aeration with the compressed air using the blowers [8]. This technology needs the permanent electric energy supply as well as the qualified personnel for the operation and maintenance. There are also the biological treatment systems with microflora fixed on the solid support (package) in the form of biological film (biofilm). These systems are well known around the world and are often defined as a standard ones, according to some experts.

**Figure 2.** Water pumping into the filtration platform [3].

The anaerobic technology is an innovation for the communal wastewaters treatment. Their principal advantage is that the anaerobic system does not need aeration, at the same time producing an energy in the form of biogas. This system represents an intensive biological treatment which needs technical, technological, biochemical knowledge and other obligatory conditions (heat, further aerobic treatment, semi-centralization, etc.) [9].

To the extensive biological purification are related most often the biologic ponds and filters artificially planted with macrophytes – the so-called phyto-purification systems (Figure 2). The extensive technologies have the considerable advantages with regard to both the investment and operation costs [10].

The common feature of extensive technologies is that they can be exploited without electricity (apart from artificially aerated biological ponds). For these reasons, the extensive options for aerobic biological treatment as well as the anaerobic treatment are considered for the rural areas more durable than the intensive ones.

**5. Biological ponds for the wastewaters treatment**

The communal wastewaters treatment in the biological ponds (lagoons) is a well-known and broadly spread technology in the Republic of Moldova. The extensive treatment is based on the natural self-purification processes with the bacterial cultures and it realized with the long-term retention of wastewaters, which needs more extended space then in case of the intensive systems. The treatment in ponds has a high performance, reduced costs and low energy consumption (sometimes equal to zero), representing a process with low maintenance costs and is very suitable for a hot climate or hot seasons [11].

The treatment in biological ponds with natural aeration is done in several dammed ponds, usually artificial, arranged consecutively [12-15]. The system is usually composed of three ponds connected in series: one optional pond and two maturation ponds. The serial placement of the three ponds allows the efficient removal of insoluble pollutants (suspended matter), biodegradable organic substances (BOD or COD) and nutrients (N and P), as well as partial disinfection. Additional ponds (with up to 6 ponds in series) are required for safe nitrogen removal or disinfection. Prior to the first pond, it is useful to consider removal of solid large size particles (usually larger than 16 mm), both sedimentable and floating.

The first pond, having a depth of 1÷2 m, has the role of removing the most of the sedimentable suspended matter, of both mineral and organic origin, as well as partial removal of biodegradable soluble organic pollutants (BOD). It can be anaerobic and may be deeper than 3 m. To avoid the methane emissions, this pond must be covered and the biogas produced should be collected.

The maturation ponds 2 and 3 are designed for the complete removal of soluble biodegradable organic pollutants (BOD), the nutrients (N and P) and pathogenic agents. Their depth is usually up to 1 m, in order to ensure the aerobic conditions (presence in water of free dissolved oxygen). The ponds should be designed in such a way that to be harmoniously incorporated in the landscape.

The efficiency of the disposal of organic matter is over 75% COD, which ensures a COD concentration in the effluent purified of less than 125 mg/L, which corresponds to the requirements of the EU Directive on the treatment of communal wastewater. Nitrogen concentration can meet the standards for areas sensitive to eutrophication in the summer, but due to the low temperature in winter the results are less good, but this is also observed in intensive procedures. Phosphorus is reduced by over 60% due to its accumulation in sedimentary sludge. Disinfection is especially important during the summer, when evacuating in small surface water receivers. The result obtained is better than in the case of intensive systems due to the long retention time and the impact of the ultraviolet solar rays.

The efficiency of the organic matter removal is over 75% chemical oxygen demand (COD), which ensures the concentration of COD in the treated effluent below 125 mg/L, which corresponds to the requirements of the EU Directive on municipal wastewater treatment. Nitrogen concentration may meet the standards for the areas sensitive to eutrophication in summer, but due to the low temperature in winter the results are not as good, but this is also observed in case of intensive procedures. Phosphorus is reduced by over 60% due to its accumulation in sedimented sludge. Disinfection is especially important in summer, when treated water is discharged into the small surface water receptors. The result obtained is better than in the case of intensive systems due to the long retention time and the impact of ultraviolet sunlight.

In order to improve the natural purification method (self-purification), it is practiced to introduce in the biological pond system an artificial aeration through the surface aerators (mechanical aeration) or blowers (pneumatic aeration). Thus, the system becomes closer to the intensive one, being similar to the aeration basins with activated sludge without recirculation. It should be noted that energy consumption can be as high as in case of the intensive sludge systems. This system usually has a total of three ponds: the first aerated pond (the first stage) and two settling / decant ponds (the second stage) connected in parallel.

The treatment in the aerated (main) pond takes place by artificial aeration and is similar to the intensive treatment, but the concentration of microflora (biomass) is much lower and the retention time is longer - about 20÷30 days. The depth of the aerated ponds is 2÷3 m if aeration with the compressed air is used.

The subsequent decant ponds in the second stage are used for the advanced treatment and secondary clarification, to ensure the sedimentation of suspended solids. The decanted sludge is periodically evacuated by pumping. The decant ponds are made in the form of rectangular basins in the ratio length: width equal to 3÷1. It is advisable to connect these ponds in parallel to evacuate the sludge. The removal efficiency of biodegradable organic pollutants (CBO) in aerated ponds is over 80%. For the efficient elimination of nitrogen, a recirculation of treated wastewater is necessary, otherwise only the nitrification is achieved. The elimination of phosphorus is limited, but can be ensured by the addition of precipitating salts (mineral coagulants).

### 6. Filters planted with artificial macrophytes / artificial wetlands

Constructed wetlands (phytofilters) are artificially created natural ecosystems for biological and physical treatment in which wastewater is introduced into the sand gravel filters on which aquatic vegetation grows [16 - 19]. Usually, the technology includes several stages (Figure 1). The filter bed can be filled with filter materials such as sand and / or gravel and is tightly insulated with natural soil (i.e. clay) or plastics. Wastewater treatment is realized through the activity of bacteria in the layer of biofilm and physical filter, and by the adsorption effects. To accelerate the treatment process, water plants are usually planted and grown, such as reed or cane, for which reason they are called reed / cane bed filters [20, 21].

Reed planted filters have been used for the first time in Germany and their use for wastewater treatment has been continued for more than 40 years, especially in the rural areas in Austria, France, Italy, Greece, Canada and other countries, for example, the Republic of Moldova (Figure 3).

**Figure 3.** Zone of water filtration through the reed, and water storage tanks [3].

Different types of systems are known; however, the superficial system is used more often, where water level is maintained below the level of the reed-planted filter surface. Depending on the mode of the wastewater flow running through the filtering layer, these systems are subdivided in two categories - with vertical flow movement (Figure 4) and with horizontal flow movement (Figure 5).

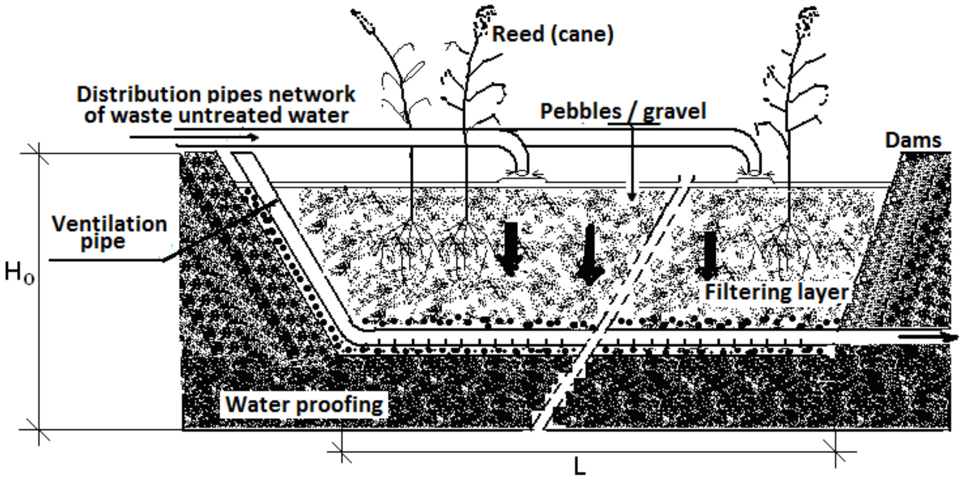


**Figure 4.** Scheme of phytofilter with vertical flow [22].

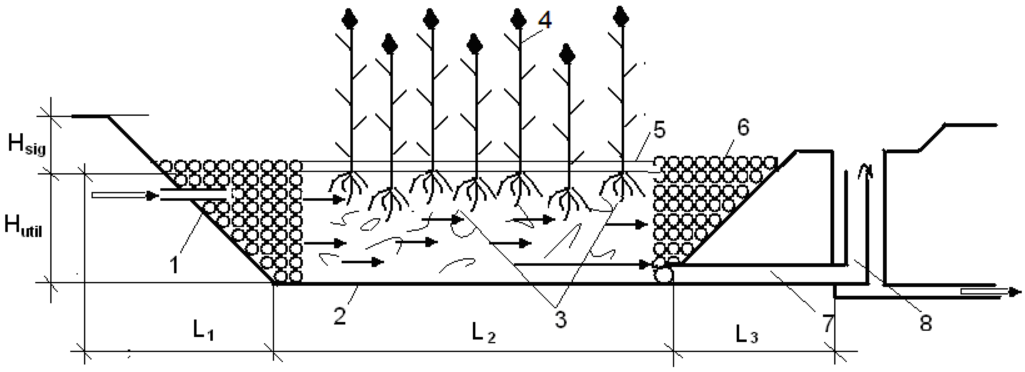


**Figure 4.** Scheme of the phytofilter with horizontal flow [22]: 1 - structure for uniform distribution of raw wastewater (made of boulders) - gabion; 2 - waterproofing; 3 - filter layer combined with the root system of plants; 4 - emergent macrophytes (reeds); 5 - wastewater level; 6 - gabion / structure for uniform collection of treated wastewater (made of boulders); 7 - exhaust pipe; 8 - flexible hose for regulating the drained water level.

Generally, the reed planted filters are used after a pre-treatment to remove, usually by sedimentation, the organic solids in order to avoid the clogging the pores of the filter layer (Figure 5).

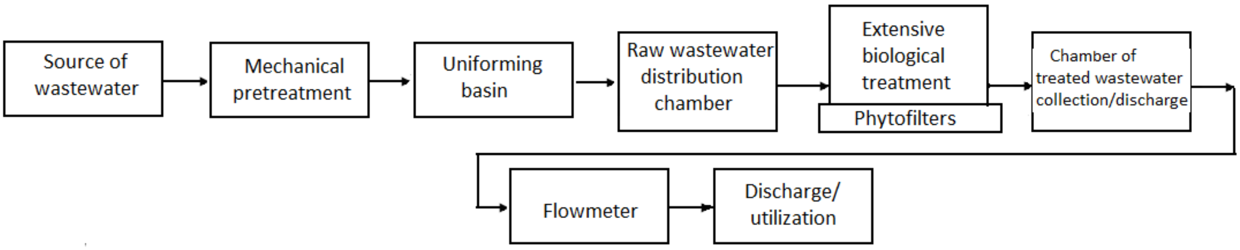


**Figure 5.** Flow sheet of the extensive biological treatment of waste waters in phytofilters (filters planted with macrophytes).

If there is no mechanical pre-treatment, the sludge can be accumulated in the in the discharge points, that produce an unpleasant odor, clogging of filter layer or even blockages of the pipes and infiltration nozzles. Pre-treatment can be carried out by passing of the raw wastewater through the grids or rare sieves and the subsequent sedimentation in decanters. For the small treatment plants, the septic tanks are used as decanters, from which the sludge is discharged, for example, once a year. For the larger treatment plants, sedimentation in the Imhoff-type multi-layer decanters is used.

An alternative pretreatment can also be performed in biological ponds. But there is a model of filters planted with reeds that do not require a pretreatment of raw wastewater, for example, in France. This is how the largest treatment plant in Orhei, Republic of Moldova, is designed. Phytofilters can be made in one, two or more steps, which allows to increase both the degree of wastewater treatment and the operational safety of the respective installations (Figures 6 and 7).

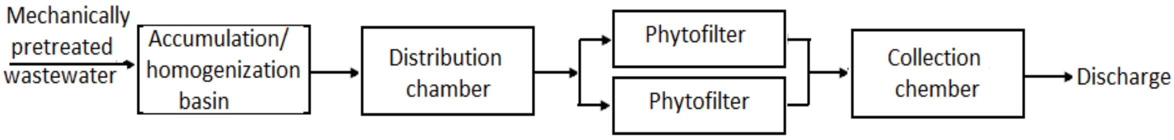


**Figure 6.** Flow sheet of natural/extensive biological treatment in the single-step phytofilters.

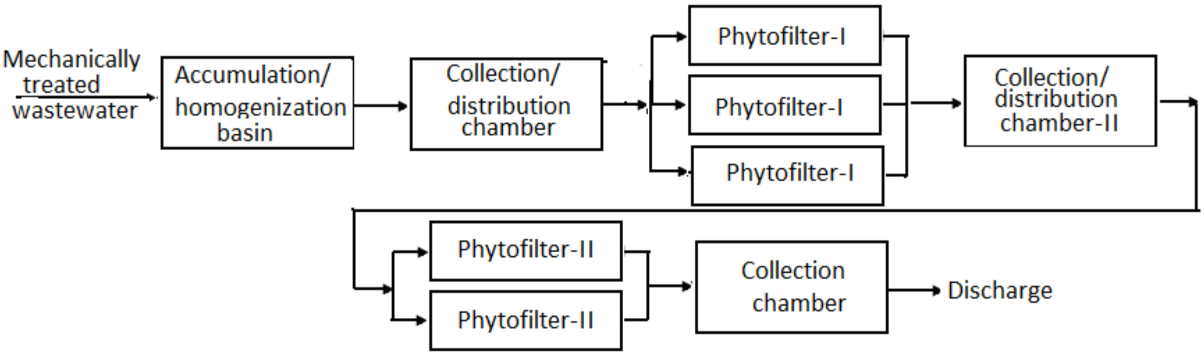


**Figure 7.** Flow-sheet of natural/extensive biological treatment in the two-step phytofilters.

Reed-planted filters applied after the pre-treatment can be a single-stage, with vertical-flow or horizontal process. The wastewater is supplied intermittently, with the sufficient pause to ensure the aerobic conditions in the filter layer, due to the oxygen-containing air penetrating into the pores. The design parameters of the reed-planted filters with horizontal flow are a necessary surface of up to 5 $m^2$ per resident connected to the sewerage system and a daily hydraulic load of maximum 40 mm; the depth of the filter bed is between 0.5 and 1.0 m. The filter body is made of the gravel and sand filling.

The vertical flow filters are dimensioned based on a specific surface area of up to 4 $m^2$ for an equivalent resident and a daily hydraulic load of 80 mm. The depth of the filter bed is 0.5 ÷ 1.0 m and it is also made of a sand gravel. A drainage system with the perforated plastic tubes is placed in the lower layer of the filter body only made up of gravel. The efficiency of the reed-planted filters with the mechanical pretreatment in the elimination of organic matter exceeds 80% expressed in COD (chemical oxygen demand). The aerobic conditions in the filters with the water level below the filter bed surface allow reaching a good nitrification capacity, although the denitrification process is limited. Only in the two-stage filters nitrogen is eliminated efficiently and the conditions for the treated wastewater discharges into the eutrophication-sensitive surface waters ("flowering" of water rich in nutrients - N and P) are observed. Phosphorus reduction depends on the absorption capacity of the filter medium, but is generally limited. Instead, it is important to eliminate pathogens, especially in the hot period.

The so-called "French method does not require the pre-treatment but the filters are designed in two stages. The wastewater supply into the filters is carried out intermittently, in case of the vertical flow, with a flow rate higher than the infiltration speed, in order to ensure a more uniform distribution of the wastewater layer on the filter bed's surface. In case of the horizontal flow the wastewater is distributed over the entire surface of the cross section of filter bed and is fed constantly. Thus, the "French system" comprises two stages, each of them using the filters connected in parallel. The first stage usually consists of three filters. Whereas the one is supplied with treated water (active), the others are passive or inactive (in a hydraulic sense). For the first stage, the area of 1.2 ÷ 1.5 $m^2$ is provided for an equivalent resident. In the upper layer of the filter bed the coarse sand is used to avoid the clogging, and the depth of the filter layer is around 80 cm. In the second stage, no less than two filters are used, which are also fed with treated water intermittently. The surface of the filters is 0.8 $m^2$ per resident, and the depth of the filters is also around 80 cm. The two-stage reed-planted filters constructed according to the "French system" ensure the elimination of organic matter by over 80% COD, allow the efficient removal of nitrogen and meet the conditions of wastewater treatment in sensitive areas. The nitrogen reduction in them is limited, whereas the elimination of pathogenic bacteria reaches 100%, being similar to that of the intensive wastewater treatment systems.

## 7. Conclusions

Analysis of the municipal wastewater treatment technologies and processes has shown that the three basic functions of sewage and water treatment comprise: protection of public health, reuse of nutrients and protection of the environment. For the system to be sustainable, the technical, socio-cultural and economic considerations must be balanced.

When selecting a sewerage system, the focus must be directed on the system operation as well as practical considerations; technology is a way to achieve the goals pursued, along with the presence of qualified staff.

The concept of phytofilters is proposed for the biological treatment of wastewater from small settlements, as shown on the examples of the Republic of Moldova. This technology is simple, relatively inexpensive and requires relatively insignificant maintenance. Biological ponds in the Republic of Moldova have shown to be very suitable for the advanced wastewater treatment, being a cheap and natural treatment system, demonstrating a good implementation potential.

This paper draws attention to a serious concept on how to radically increase an access to the basic sewerage and sanitation system through the technology that meets the principles of economic efficiency, social equality and environmental sustainability. This is the beginning of an integrated and sustainable management of Europe's water resources. For sewerage water convey and the treatment of communal wastewater, a new selection concept is proposed for practical implementation, especially in the rural and suburban localities, local/decentralized, semi-decentralized and centralized systems. To reach the scopes of environmentally-friendly and economically justified water treatment, the more suitable systems for the given locality must be chosen primarily, taking into account the particularity of the settlement, in terms of the treated wastewater and sludge reuse in agriculture, the advantages and disadvantages of the systems.

In the wastewater treatment, a priority should be given to the natural biological treatment processes, along with the intensive biological treatment processes, especially when treating the industrial wastewater containing the products, which would cause damage to agriculture. In this case, priority should be given to the fixed or hybrid microflora.

**Acknowledgement:** This work was performed under the National Research Project No. 20.80009.5007.04.

**Conflicts of interest:** The authors declare no conflict of interest.

**References**

1. Bodic, I.; Ridderstolpe, P. (Eds.) *Sustainable health in Central and Eastern Europe – solution for solving the wastewater problem in small and medium-sized villages and communes*. Global Water Partnership. Central and Eastern Europe, 2007, p. 89
2. Wenland, C., Albold, A. *Sustainable and efficient wastewater treatment systems for rural and suburban communities with up to 10,000 PE*. Guide, WECF, 2010, p. 30.
3. The water purification station in Orhei (photo). Available at: www.http://diez.md/wp-content/uploads/2014/05/IMG (accessed on 01 February 2023).
4. Shaw, R.A. C*ollection of Contemporary Toilet Designs*. EOOS and WEDC, Loughborough University, UK. 2014, p. 40.
5. Rosemarin, A.; McConville, J., Flores, A.; Qiang, Zh. *The Challenges of Urban Ecological Sanitation: Lessons from the Erdos Eco-Town Project*. Practical Action Publishers, 2012, p. 116.
6. Gernaey, K.V., Sin, G. Wastewater Treatment Models. *Encyclopedia of Ecology* 2008, pp. 3707-3718. https://doi.org/10.1016/B978-0-12-409548-9.00676-X
7. Vera, J.D.; Stadler, L.B.; Martin, K.J.; Raskin, K.J. Prospects for Biological Nitrogen Removal from Anaerobic Effluents during Mainstream Wastewater Treatment. *Environmental Science & Technology Letters* **2015, 2, pp.** 234-244.
8. Scholz, M. Activated Sludge Processes. *Wetlands for Water Pollution Control* 2016, pp. 91-105. https://doi.org/10.1016/B978-0-444-63607-2.00015-0.

9. McCarty, P.L.; Smith, D.P. Anaerobic wastewater treatment. Environmental Science and Technology 1986, 20 (12), pp. 1200–1206.
10. Zhenbin, W., Yicheng, X., Jiadl, D. Studies on Wastewater Treatment by Means of Integrated Biological Pond System: Design and Function of Macrophytes. *Water Science and Technology* 1993, 27 (1), pp. 97-105.
11. Effebi, K.R., Juspin, H., Keffala, C., Vasel, J.L. A model for anaerobic ponds combining settling and biological processes. *Water Science and Technology*, 2013, 67 (12), pp. 2663-26699.
12. Rajbhandari, B.K., Annachatre, A.P., Vasel, J.L. Modeling of anaerobic treatment of wastewater in ponds. *Water Science and Technology* 2007, 55(11), pp. 47-56.
13. Phuntso, S.Wastewater stabilization ponds for wastewater treatment. In: *Water and wastewater treatment technologies*. Encyclopedia of life of support systems (EOLSS), 2014, p. 33.
14. Waron, M.A.; Mara, D.D. *Waste stabilization ponds*. Delft: Intl. Water and Sanitation Centre, 2004.
15. Tilley, E. *Waste stabilization ponds*. EAWAG, 2014.
16. Albold, A. *Constructed wetlands: Sustainable wastewater treatment for rural and periurban communities in Bulgaria*. Case study. 2007, p. 21.
17. Gauss, M. *Constructed wetlands: a promissing wastewater treatment system for small localities*. Experience from Latin America. 2008, 55 p.
18. *Constructed wetlands manual*. UN – HABITAT. 2008, p. 90.
19. Vyzamal, J. Constructed Wetlands for Wastewater Treatment: Five Decades of Experience, Environmental Science and Technology. *Environ Sci Technol* 2011, 45 (1), pp. 61-69.
20. *Evaluation Study of Natural Treatment Systems for Wastewater Management in Rural Communities: Joint Operational Program Black Sea Basin 2007-2013*. Univ. Democritus from Thrace. WASTEnet, Chisinau: Eco-TIRAS, 2014, 84 p.
21. *Educational material on Natural Treatment Systems in Wastewater Management of Rural Communities. Black Sea Basin 2007-2013*. Joint Operational Program Black Sea Basin 2007-2013. WASTEnet, Chisinau: Eco-TIRAS, 2014, p. 16.
22. Ungureanu, D.; Covaliova, O. Code of Practice in Constructions CP G.03.01:2016 Systems of natural biological purification of municipal wastewater in filters planted with macrophytes (phytofilters). ICȘC "INCERCOM" Î.S., 2016, 89 p.

**Citation:** Covaliov, V.; Ungureanu, D.; Duca, Gh.; Covaliova, O.; Romanciuc L. A new concept regarding the selection of sewerage systems and natural treatment of municipal wastewaters. *Journal of Engineering Science* 2023, 30 (1), pp. 128-139. https://doi.org/10.52326/jes.utm.2023.30(1).11.



**Submission of manuscripts**: jes@meridian.utm.md