Possibilities of usability of sediments flowing into a combined sewer network

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Abstract. Primarily there are gravel and sand particles contained, which are, together with the surface runoff, discharged through the rainwater inlets into the sewer system. The concentration of such sediments varies depending on the urbanization density and built infrastructure in the site. In the part of cities with increased occurrence of trees and greenery are the sediments mostly of organic origin (leaves, grass, branches, etc.). With fully functional urban stormwater drainage are these sediments collected directly in the drain inlets and during the dry weather conditions discharged by the authorized persons into the maintain truck. In our research, we focus on the quantity of the rainwater runoff sediments in general view while analysing the possibility and methods of utilization of these sediments.

1. Introduction
During rainfall, rainwater runoff is created on the impermeable surfaces, which is drained to the sewerage system through rainwater gullies. Stormwater drain inlets (also known as gullies) are an essential part of the sewer system responsible for collecting and draining excess water from infrastructure. These objects are commonly designed as gully pots, referring to the presence of a sand trap [1]. However, it is well known that wastewater and urban runoff transport a variety of solid particles that can create obstructions in the sewer system, thus deteriorate its operation. Sediment related blockages may result in the release of raw sewage into the environment due to a reduced hydraulic capacity that increases the probability of local sewer congestion and relating events, e.g. sewer system overflow [2]. By capturing suspended particles from the runoff, silting, and wear of downstream sewer components are reduced [3]. The gully pots contribute to reducing the pollutions of receiving water bodies, especially during storm events. Nowadays, it is widely recognized that the accumulation of sediments in the urban sewer system can lead to its congestion, flooding, premature overflow, and water pollution [4].

The composition of sediments is varied and depends on the urbanization of the site. From the areas with an increased occurrence of vegetation, sediments are predominantly of organic origin (leaves, grass, branches, etc.) on the contrary to the sites that are mostly paved with concrete and asphalt. Rainwater runoff collects these sediments into the specialized baskets situated in gully pots. These baskets are emptied during the dry weather season by road maintenance personnel and are further processed either for recovery (composting) or disposal, depending on the level of contamination. The frequency of cleaning gully pots depends on the maintenance budget, location, or vulnerability of the urban environment. The effectiveness of this type of management depends on the number of blockages in the system within the specified interval [5]. If data on the operational condition of gully pots are utilized to
determine the maintenance interval, it is possible to balance the effectiveness of strategies and the associated resources to provide cost-effective service provision [1].

This study focused on solving the current state of use of sediments flowing into the combined sewer network and their future effective method for recycling, in order to improve the current state of waste management in cities and municipalities.

![Figure 1. Gully pot with sediments by flowing rainwater (Authors, 2019).](image)

2. Methodology

At present, there is still no exact definition of biodegradable waste. Literature reviews and legislation define biodegradable waste in different ways.

Biodegradable waste is waste that is able to be decomposed by an anaerobic or aerobic way, in particular: food waste, paper, and paperboard waste, garden and park waste [6]. This general definition is taken from the European Directive 1999/31/EC on the landfill of waste.

Bio-waste is a biodegradable garden and park waste, food waste, and kitchen waste from households, restaurants, catering and retail establishments, and comparable food business waste [6]. This definition of bio-waste does not include, for example, forestry, agricultural, manure, sludge, and other biodegradable waste such as natural textiles, paper or processed wood [7].

The Waste Management Program and the Landfill Restriction Strategy mainly focus on the sorting of components of this type of waste that need to be reduced in landfills. By joining the European Union, each member state has committed to meet the objectives set in the European Union's directives. Similar acting is expected from the countries outside the European Union. The main aim of the European Union is to reduce the landfilling of biodegradable municipal waste. Bio-waste should be managed by the waste hierarchy established by the European Directive, which gives priority to the prevention and recovery of waste over its disposal based on the strategy for the circular economy. The most suitable forms of recovery of biodegradable waste include composting and anaerobic digestion. European legislation on the management of biodegradable waste gives the Member States the freedom to choose the most appropriate form of treatment and recovery of this type of waste, but the conditions and requirements laid down in the Directives must be respected.

Based on expert estimations, bio-waste represents from 40 to 45% of the total amount of municipal waste. Early, the production of municipal waste is expected to increase in the European Union, in connection with increasing living standards and a higher rate of urbanization. Therefore, it will mainly depend on the residents, whether they will separate waste and increase the level of separation of municipal waste.

Biodegradable municipal waste has nowadays an excellent potential for reuse since this waste does not dispose of harmful properties. When choosing the method and technology of biowaste treatment, it is necessary to know the amounts and types of bio-waste, as they have different physical properties and
chemical composition and, therefore, may not be suitable for the chosen treatment method. The problem arises in the improperly chosen way of the handling and disposal of waste, such as landfilling and incineration. These methods of waste disposal produce substances that adversely affect the environment. From a microbiological and the water eutrophication point of view, the sludge from sewage treatment plants, fertilizer wastes from agricultural production, and kitchen and restaurant wastes are hazardous biowaste. Risks can be eliminated by the correct method and technology of biowaste treatment [8].

Before selecting a suitable method for processing or disposal, it is necessary to monitor the qualitative and quantitative parameters of the selected site. It is also required to follow the ratios between paved and pervious areas, the function of buildings, and the quantity of the greenery around. During the monitoring of the samples of sediments from gully pots, parameters such as mass, humidity, pH, heavy metal concentration, volatile substances, and sediment composition should be mainly controlled. Based on the information obtained from the monitoring of sediments, the most effective method for further waste management - its disposal or recovery, will be proposed.

3. Possibilities of usability of sediments

All the produced wastes must be treated, disposed of or recovered in an appropriate way. The choice of method is mainly based on the characteristics of the waste. Regarding biodegradable waste, it can be disposed of or recovered by various processes having different environmental impacts. Landfilling and incineration are the most harmful ways for disposal of biowaste. By using other treatments, we can more effectively use the potential of this type of waste while reducing negative environmental impacts among such methods of processing, respectively. Such techniques include composting, anaerobic digestion, mechanical-biological treatment, energy-related processing, and biofuel production (such as chips, pellets, briquettes, alcoholic fermentation, and esterification). When choosing the method and technology of biowaste treatment, it is necessary to know the amounts and types of bio-waste, as they have different physical properties and chemical composition and, therefore, the chosen treatment method may not be the most suitable one [8].

3.1. Landfilling

Biodegradable waste that is disposed of by landfilling is harmful to the environment since it produces landfill gas and leachate. Landfill gas contains methane and carbon dioxide, which are greenhouse gases. If they are not trapped and escape freely into the atmosphere, they contribute significantly to the greenhouse effect. Methane is particularly problematic because it is able to capture approximately 20 times more infrared energy than carbon dioxide [9]. In addition to landfill gas, landfill leachate may also harm the environment, as it may contaminate groundwater and soil if landfill sealing and containment systems are not provided or are broken. Since landfilling generally has many adverse effects on the environment, there is a tendency to limit this type of disposal. Nor this disposal method is considered to be a sustainable solution in waste management [10].

3.2. Combustion

Incineration of biodegradable municipal waste in waste incineration plants is also not considered as an environmentally friendly way of disposal because it generates toxic gases (e.g. dioxins) due to its high humidity and salt (chlorine) content. In addition to dioxins in the presence of chlorine, the combustion of this type of waste also produces highly aggressive hydrochloric acid, hazardous chlorinated hydrocarbons, and furans. Burning bio-waste from gardens is also a burdensome element for the environment. The smoke produced by this imperfect combustion process contains harmful substances for human health, such as carbon monoxide, various hydrocarbons, tars, but also the dioxins mentioned [8].

3.3. Composting and Anaerobic digestion

Composting and fermentation processes are among the methods of processing various types of bio-waste. The aim of the biological processing of organic material is its highest possible microbial degradation (stabilization). Deodorization (odor removal) is also achieved in this way. Biodegradable municipal waste from urbanized areas often needs to be further cleaned (metal, plastic, glass) and
pasteurized. Therefore, a sorting and pasteurization line is included before the mechanical treatment step of the substrate.

3.3.1. **Composting.** Composting is a natural biochemical process in which microorganisms degrade organic material in the presence of oxygen. The resulting products of the process are carbon dioxide (CO$_2$), water (H$_2$O), heat, and compost. Composting is an adequate way of recovering organic waste, since in terms of ecosystem and sustainable development, composting by the natural cycle of biogenic elements is associated with natural energy transfer and biological matter degradation [11].

The composted material must contain both a sufficient amount of degradable organic components and nutrients without the presence of harmful substances. The most commonly used materials for composting include bio-waste such as green garden waste, garden and park waste, industry and municipal waste with a similar composition of household (municipal) waste [11].

The final quality of compost is influenced by several major technological factors, such as the composting method chosen and the physical, chemical, and microbiological properties of the composted raw materials. Other factors include composting time, formula recipe, preparation of raw materials before composting and storage, monitoring of the composting process, and the final maturity and stability of the compost [12].

3.3.2. **Anaerobic digestion.** Anaerobic digestion (methane fermentation, methanization or anaerobic composting) is a process in which the biodegradable organic matter gradually decomposes without access of air. Several groups of anaerobic microorganisms are involved in this process, where the product of one group becomes the substrate of the other, so the failure of one group can disrupt the entire process system. The final product is biogas and non-degradable residues of organic matter (so-called digestate), which is stabilized from the hygienic and sensory point of view [13].

The main product of anaerobic digestion is biogas. Biogas is a colorless gas whose main components are methane (55-75%), carbon dioxide (23-43%), and hydrogen (around 2%). The advantage of fermentation as opposed to composting is the possibility of processing and recovering liquid organic wastes such as canteen liquid wastes, cooking oils, greases and fat-trapping contents or bio-waste contaminated with no toxic components such as heavy metals. Furthermore, organic municipal and industrial waste - kitchen waste, garden waste, and various organic waste from the garden - is processed; organic special agricultural wastes (possible manure treatment), municipal sewage sludge produced in aerobic wastewater treatment stage and specific industrial wastes. From the environmental and economic point of view, mixing household waste with sludge or waste contaminated with toxic components is necessary [11].

4. **Conclusion**

Sediments from drain gully pots can be recovered or disposed of by various methods. According to the analysis of these techniques, it can be concluded that the most optimal process for the treatment of sediments from gully pots is anaerobic digestion. The advantage of this method is that contaminated heavy metal materials can also be further processed. In the presence of higher oil concentrations in sediments, it is necessary to mix with contamination-free materials to optimize the treatment process. Treated waste in a biogas plant can be used as an organic fertilizer if it complies with the limits of foreign substances (especially in the case of heavy metals), or it can be composted or treated for agricultural substrates.

5. **References**

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