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Review: Reuse of Treated Wastewater

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Abstract: ***Water reuse generally refers to the process of using treated wastewater (reclaimed water) for beneficial purposes such as agricultural and landscape irrigation, industrial processes, nonpotable urban applications (such as toilet flushing, street washing, and fire protection), groundwater recharge, recreation, and direct or undirected water supply. Its increased application has been facilitated by modern wastewater treatment processes that have advanced substantially during the twentieth century. Water Reuse is a reality at international. Several practices have emerged around the world as results of different needs, perspectives and policies. Accelerating development occurred in the past 15 years, especially in the application field of potable reuse. Technologies and treatment flowsheets have been studied and validated, demonstrating advanced water quality, safety and suitability for potable reuse applications. Reuse of wastewater after its treatment may be a good alternative for regions, which suffer from lack of pure water or have limited access to water resources. Effective water reuse applications require a combination of advanced treatment technologies. Increasingly these include a combination of low-pressure technologies MF/UF followed by NF/RO (high pressure) to provide a high-quality grade of water. Submerged membrane bioreactor systems (MBR) have also become a viable alternative for wastewater reuse technologies. Reuse technologies may be applied for municipal and industrial wastewater. Reuse of wastewater is only possible if sanitary and environmental safety is provided with no hazard for current ecosystem. That fact requires strict fulfilment of laws and regulation. Wastewater to be reused has to follow a certain sequence of treatment procedures to reduce concentration of pollutants in it. Water reuse (also commonly known as water recycling or water reclamation) reclaims water from a variety of sources then treats and reuses it for beneficial purposes such as agriculture and irrigation, potable water supplies, groundwater replenishment, industrial processes, and environmental restoration. Water reuse can provide alternatives to existing water supplies and be used to enhance water security, sustainability, and resilience that might be traditional methods (waste separation, sedimentation), methods of removal of certain components (nitrogen and phosphorus), disinfection.***

Keywords: Waste Water Treatment, Pulp &Paper Mill, Reuse water, Industrial Waste

I. INTRODUCTION

Reuse of wastewater after appropriate treatment can successfully contribute to the solution of the emergency situations that may happen in regions with insufficient water resources. Household drains as well as municipal or industrial can be recycled. Reuse is allowed, if full environmental safety will be ensured (i.e. no harm the existing ecosystem, soil and cultural plants), and any sanitary risk for the local population will be eliminated [1].

This requires strict following to existing regulations in protecting health and safety, as well as current codes for industry and agriculture. Water reuse (also commonly known as water recycling or water reclamation) reclaims water from a variety of sources then treats and reuses it for beneficial purposes such as agriculture and irrigation, potable water supplies, groundwater replenishment, industrial processes, and environmental restoration [2].

Water reuse can provide alternatives to existing water supplies and be used to enhance water security, sustainability, and resilience. Water reuse can be defined as planned or unplanned. Planned water reuse refers to water systems designed with the goal of beneficially reusing a recycled water supply. Often, communities will seek to optimize their overall water use by reusing water to the extent possible within the community, before the water is reintroduced to the environment [3]. Examples of planned reuse include agricultural and landscape irrigation, industrial process water, potable water supplies, and groundwater supply management.

A critical aspect for wastewater reuse is that the quality of wastewater must be appropriate for its reuse. There are several different types of wastewater produced at the household level that have very different levels of contaminants (i.e. nutrients, pathogens) and reuse potential, including rainwater, greywater (all household wastewater except toilet flushing water), urine and black-water[4]. Separating these streams of wastewater reduces the amount of wastewater contaminated by pathogens (i.e. black-water, urine) by preventing it from coming into contact with less contaminated water (i.e. greywater, rainwater), thereby allowing greywater and rainwater to be used for a wider range of purposes

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II. WASTEWATER REUSE

Wastewater reuse is a solution for the future to combat water scarcity. After treatment, wastewater can be used for a variety of applications including watering green spaces and golf courses, crop irrigation, fire-fighting and street-cleaning, or it can be used to recharge aquifers. Operators and owners of wastewater treatment plants and authorized standalone sanitation plants that reuse wastewater are eligible for financial aid from the water basin agency, in accordance with conditions set out in the legislation. In most cases, water to be reused requires pre-treatment [5]. The degree of such treatment is determined by the requirements of sanitary safety and costs.

Reused water after purification also requires additional pipeline. There are three main options appeared considering reuse of water : - irrigation: irrigation of cultivated plants intended for the production of food for further consumption by people or pets, as well as non-food products; watering of areas for landscaping, gardens, parks and sports facilities; civil - purpose: washing the pavements and sidewalks, water supply of heating networks and air-conditioning systems, water supply of secondary water distribution networks (separate from drinking water) avoiding direct use of this water in buildings with the exception of the drain system of toilets and bathrooms; -industrial application: the supply of fire distinguishing systems, industrial circuits, washing systems, thermal cycles of industrial processes avoiding application involving secondary contact of reused water with food, pharmaceutical and cosmetic products.

Before recycling of the regenerated water it is necessary to provide a certain level of quality, especially in relation to health and hygiene requirements [6]. Water that is of a relatively high quality with few contaminants, such as rainwater or greywater, can be directly reused. Numerous technologies exist for household precipitation harvesting, while greywater can be collected by refitting pipes to divert wastewater from appliances like showers, washing machines, and sinks.

1) Even though water for direct reuse may be relatively free of contaminants, the future reuse of rainwater and greywater must be appropriate for the level of contaminants present. Appropriate purposes for direct reuse can include:
2) Washing (cars, etc.)
3) Flushing toilets
4) Gardening and food production can be done with greywater towers, vertical gardens, fertigation, drip-irrigation, and subsurface drip irrigation

Traditional methods of treatment of water for reuse is insufficient to ensure this quality. There are new alternative technologies for cleaning and disinfection appearing, with help of which it is possible to reduce the content in water of microbes, nutrients, toxic substances and reach the required level of water quality at relatively low cost [7].

The regulations represented the minimum acceptable quality parameters that water should have after regeneration if forwarded to recycling.

For water intended for industrial use, the maximum permissible values are set depending on the specific production cycles. The construction of the wastewater reuse system and its' subsequent use must be approved by the authorities and are subjected to periodic inspection [8].

The distribution network of the recycled water must be specifically marked and differ from the networks of drinking water, in order to completely eliminate any risk of contamination of water supply network for drinking purposes.

Uses for Recycled Water

- Examples of water sources and use applications:
- Irrigation for agriculture
- Irrigation for landscaping such as parks, rights-of-ways, and golf courses
- Municipal water supply
- Process water for power plants, refineries, mills, and factories
- Indoor uses such as toilet flushing
- Dust control or surface cleaning of roads, construction sites, and other trafficked areas
- Concrete mixing and other construction processes
- Supplying artificial lakes and inland or coastal aquifers
- Environmental restoration

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III. TREATMENT OF WASTEWATER FOR FURTHER REUSE

The method of sewage treatment in each specific case depends on the desired product quality and may include the following types of processing: - pre-treatment: screens (to remove large solid particles), sand traps, pre-aeration, extraction of oil particles; - Primary treatment via sedimentation in special tanks to settle a significant part of the deposited particulate matter, understand the need for a particular degree of wastewater treatment, the concept of water quality management must be introduced. Water must be used and treated in such a way that deleterious effects are minimized, both for the environment and for the next user [9]. From an engineering perspective, the intended use of a water should be determined, water quality requirements for that use delineated, and then treatment or other management techniques based on those requirements accomplished. The dictionary defines pollution as something that makes the water physically impure, foul or filthy, dirty, stained, tainted, or defiled [10]. Actually, the addition of anything to a water that adversely changes its existing quality constitutes pollution, including heat and sediment. Pollution may be caused by both humans and nature, and the effects may be similar. The process can be speeded up by use of chemical additives (flocculants); - Secondary treatment with the use of aerobic bacteria that provides biological destruction of organic load and biological oxidation of organic matter dissolved in the wastewater. – Treatment processes with suspended biomass (active sludge); – Removal nutrients (nitrates and phosphates); – Nitrification, denitrification, dephosphorization: wastewater treatment processes that provide, respectively, the transformation of organic nitrogen into nitrates, the decomposition of nitrates with formation of gas nitrogen and removal from waste water soluble salts of phosphorus; – Final disinfection is used to provide sanitary and hygienic safety wastewater[11]. The technique involves the use of reagents based on chlorine or ozone, or treatment with ultraviolet irradiation. In addition to the above ways there are two technologies of natural wastewater treatment, which may be used as cleaning second or third level – constructed wetlands and bioponds. Both technologies are used primarily in small wastewater treatment plants or in areas where there is the opportunity to use the extensive grounds. There is a gradual biological degradation of pollution by microbial colonies (due to aerobic or anaerobic metabolism) or algae presented in the pond. It is convenient to classify pollutants into four categories as follows: chemical, physical, physiological, and biological. A brief discussion of these is in order as is their method of removal[12]. It should be noted that, depending on the intended use of the water, every receiving water will have a limit as to how much of each of these kinds of wastes can be discharged into the water without adverse effects. Chemical pollutants can be broadly categorized into inorganic and organic pollutants, where organic materials may be defined as those compounds containing organic carbon. The major problem with organic materials is their conversion to carbon dioxide and water as follows:

Organics+microorganisms+oxygen+nutrients→$C0_2$+H_20+moremicroorganisms

In as much as aquatic life requires a certain level of dissolved oxygen to live and propagate, it is obvious that if sufficient organic material is placed into the water, oxygen levels may be reduced to inimical concentrations.

IV. IMPLEMENTATION OF REUSED WASTEWATER

Wastewater of industrial enterprises contain specific contaminants that must be removed before mixing with effluents of the other proceedings or settlement. Existing domestic and foreign experience indicate the possible implementation of a closed system by reusing treated wastewater [13]. The sense of reuse of treated wastewater in the systems of industrial water supply fully depends on specific local conditions; the technologies used and is mainly determined by the possibility and expediency of use of:

1) Wastewater in the systems of circulating and repeated water supply for enterprises or single workshops;
2) Treated and disinfected domestic waste water in the technical water supply for enterprises or single workshops;
3) Treated sewage of one companies for technical water supply of other enterprises or shops.

The choice of purification method depends on the concentration of pollutants in wastewater and amounts of solid waste generated in primary production and at the stage of purification, and also from the ecological-economic indicators of the process. The most popular technology today - the so-called dual system. Conventional water network for drinking purposes is located next to a second one that deliver already treated wastewater.

This water can be used for the following purposes:

a) Domestic process water for toilets in cases that do not involve direct human contact (i.e. mainly to drain toilets);
b) Watering of green plantings of landscape areas, athletic fields, fields for playing golf, etc;
c) Washing of streets, sidewalks, pedestrian crossings, etc;
d) Water supply of decorative fountains;
e) Washing of vehicles.

There are also effective technologies of purification of water to be reused in separate units of toilets. The waste water of the bathtubs and showers is filtered to remove soap and dirt, and following goes for a toilet flush, or to any other technical needs, e.g. for washing the car or watering the garden. Such systems are suitable for private houses, private apartments, small hotels, clubs, etc. The results of the experiments showed that the actual consumption of the resources such systems reduces twice in conventional homes and up to 40% in hotels and shopping malls. Key benefits - full autonomy of the water supply system with no possibility to contaminate potable and technical water, no chemicals and harmful byproducts, significant energy efficiency (to power the pump uses a DC source voltage of 12 W), possible use of solar energy, fully automatic cleaning cycles,exchangers), and fire safety (sprinkler system water). For use in heating, the boilers of wastewater should pass through a clarification by flocculation, then filtered and demineralized. Almost every industrial process or operation requires the use of water: - Preparation of steam boilers and humidifiers; - Heat transfer in heating systems, pyrocondensate, cooling liquid and solids; - flushing of solid particles and gas purification; - baths for the surface treatment of various kinds. In cases, when manufacturing require large volumes of water, treated wastewater can be used for this purposes, for example, in the textile industry, pulp and paper, dyeing workshops and metallurgy. Significant variety and diversity of production require different quality of reused water that in fact means significantly different approaches and methods of its treatment. Recycled water in agriculture gives considerable savings in consumption of water resources, as the consumption of water in agricultural area is significantly higher than consumption in the civil sector and industry. It should be taken into account that the use of recycled water in agriculture is not always possible, especially when chemical composition of wastewater is incompatible with agriculture (high concentrations of sodium and calcium compared to potassium and magnesium)

In individual homes, condominiums, hotels, rain water (figure 5) that is collected in the accumulation tanks can be successfully used in working circuits of sanitary appliances, washing machines, cleaning, watering plants, washing cars. Approximately 50% of the daily requirement of water in the private sector can be provided by the use the recycled rainwater. Rainwater in fact does not require any special cleaning, just a simple filter as it drains on the roofs of buildings and into storage tanks. The reuse of treated wastewater for process water in some parts of the country may reduce existing deficit of freshwater resources to zero.

V. CONCLUSIONS

Reused water may be a vital alternative to fresh water especially in the regions with water deficit. Water to be reused requires a certain treatment according to the further implementation, however reuse of wastewater is not always possible. Accumulation and reuse of rainwater allows saving up to half of fresh water need for various domestic needs. The reuse of wastewater for agricultural purpose can help to mitigate the problem of water stress, food security and treatment of wastewater rural and urban areas. Water recycling and reuse is meant to help close the water cycle and therefore enable sustainable reuse of available water resources, addressing the water security issues. Thus, our study can be utilized to attain success and sustainable management of wastewater as effective quality, which can contribute to the challenges of water scarcity.

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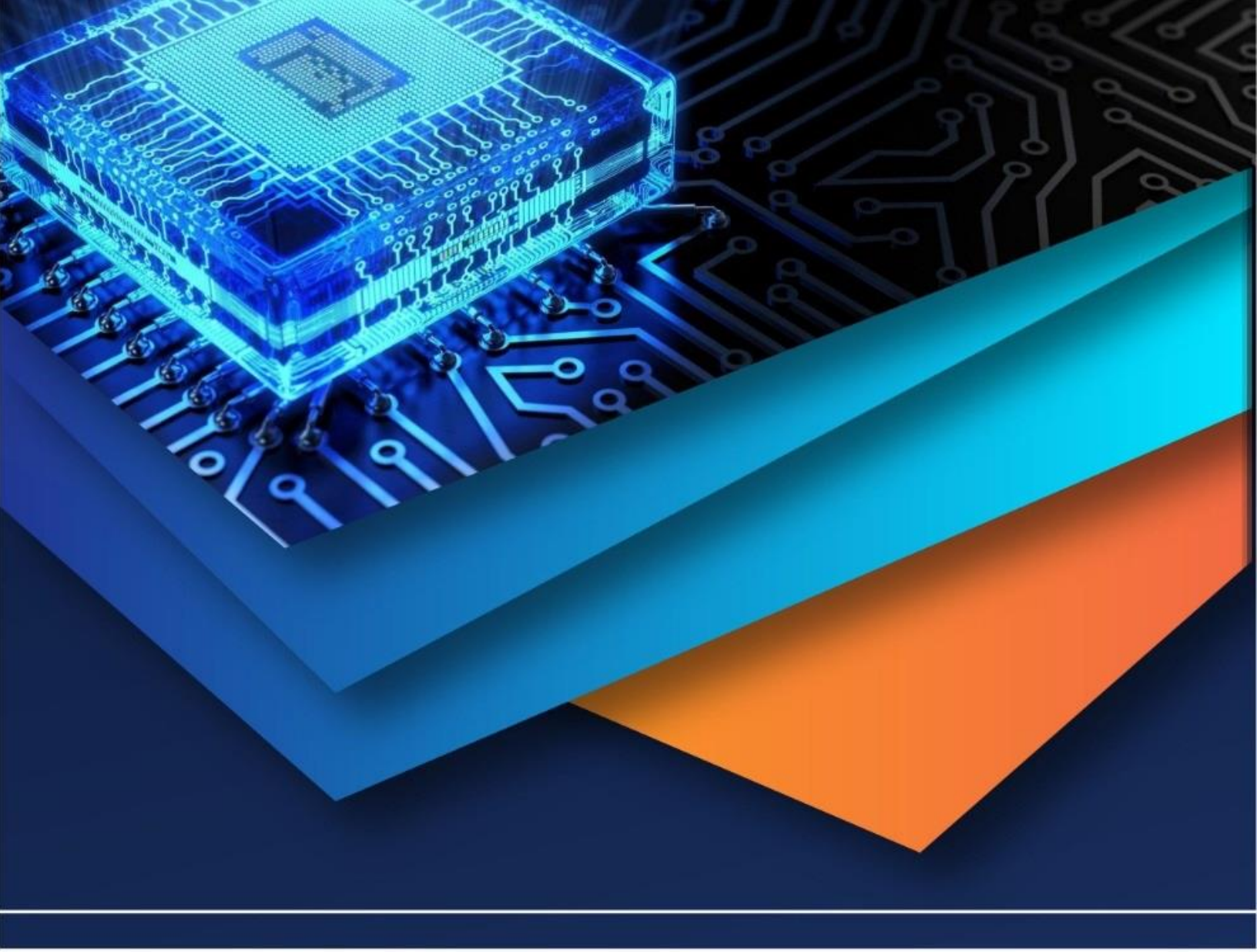

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