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Short Commentary

Resource Recovery from Wastewater

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Introduction

The fundamental objective of designing a wastewater treatment plant is to return the surface waters in pristine conditions so as not to harm the receiving water bodies. Wastewater treatment plants play an important role in protecting our environment. Current wastewater treatment plants are mainly predominant in aeration based technology known as "activated sludge" process which has been proven to be a robust and reliable technology over the last century treating a variety of wastewater streams originating from various sectors [1,2]. The activated sludge process requires oxygen as a key ingredient to remove the biologically degradable organic matter in wastewater. Air supply to meet this oxygen requirement is also the key contributor for energy and operating costs in the process. Approximately, fifty percent of operating costs are associated with pumping oxygen into the activated sludge reactor [3].

Aeration based treatment technology was developed in times of the greatest need to protect surface water sources. This became the predominant technology when there were no significant concerns for the lack of energy sources. In recent decades, due to population growth and rapid industrialization and associated energy consumption, the need for developing more energy and resource-efficient technologies has become apparent [2]. Resource-efficient technology means that not only energy consumption should be minimized rather it should be recovered along with other valuable resources including nutrients, nitrogen and phosphorous. Water, itself, is the most valuable resource that can be recovered from these operations [3]. Considering the global challenges for water, energy and nutrients and food supplies, it is important to consider a paradigm shift in understanding and therefore redesigning our wastewater treatment systems.

Wastewater treatment system design and operations should now look beyond achieving environmental protection through reduction approach which is simply removing biodegradable and nutrient sources, often considered problematic for various reasons. However, these sources can be recovered or put to beneficial use in a recovery approach if appropriate technologies can be developed (see Figure 1). Wastewater contains up to ten times more energy than it is required to treat it [4]. This energy is present in the form of organic and inorganic "contaminants" and thermal gradient. In aerobic processes, about 40% of the organic waste is embedded into new biomass called sludge and 50% is converted into carbon dioxide through microbial metabolism which is released into environment and not considered an environmental emission by the United States Environmental Protection Agency and the remaining is considered non-biodegradable. About 1500 tons of carbon dioxide is released for every 1000 tons of wastewater is treated [3]. In reality, these emissions can be considered a significant contribution to man-made pollution when all the wastewater treatment plants around world are combined. Therefore, alternative technologies that diminish environmental emissions should be developed. These technologies should address energy, nutrient and water related issues intertwined with wastewater treatment.

Energy Scenario

Current water and wastewater treatment schemes in developed countries such as the United States of America and United Kingdom consume up to 5% of the national electric load [5]. This demand is several fold higher when the energy budget for small communities is evaluated [3]. Anaerobic treatment processes are also well known around the same time as the aerated technologies. Due to slow removal rates, the aerated technologies have become superior. In anaerobic treatment process, organic carbon can be partly converted into methane (biogas) and carbon dioxide. Methane can be used for heating applications within the plant operations to reduce operation energy requirements.

Another anaerobic technology that directly converts organic carbon into electricity is called a microbial fuel cell [6,7]. In this process, exoelectrogenic (electron producing) bacteria fed by organic carbon in the anode chamber convert it into carbon dioxide and release electrons which are harvested through an electric circuit connected to an electron accepting cathode chamber. This process can also be modified to remove or recover other valuable chemicals and metals or even produce biofuels [8-10].

Integrating heterotrophic and photosynthetic processes for conversion of organic compounds into the lipid-rich biomass is another efficient approach for biofuel production. This also helps address the energy consumption and environmental emission issues involved in wastewater treatment [2]. When wastewater treatment and biofuel production are combined in a microalgae system, energy returns are more favorable [11,12]. Energy-efficient anammox process can be considered for sludge reduction and nitrogen removal as reported in recent investigations [13,14]. Wastewater influent temperature gradient may be harvested though heat cycles for beneficial use as well. Finally, a small portion of energy may be recovered if the wastewater treatment plant is located geographically at a position that provides adequate hydraulic head for electricity production [3].

Nutrient Scenario

Nitrogen (N) and phosphorous (P) are considered the major nutrients essential for life. Nutrients are required for agriculture, farming, domestic gardens and aquatic environments. The same

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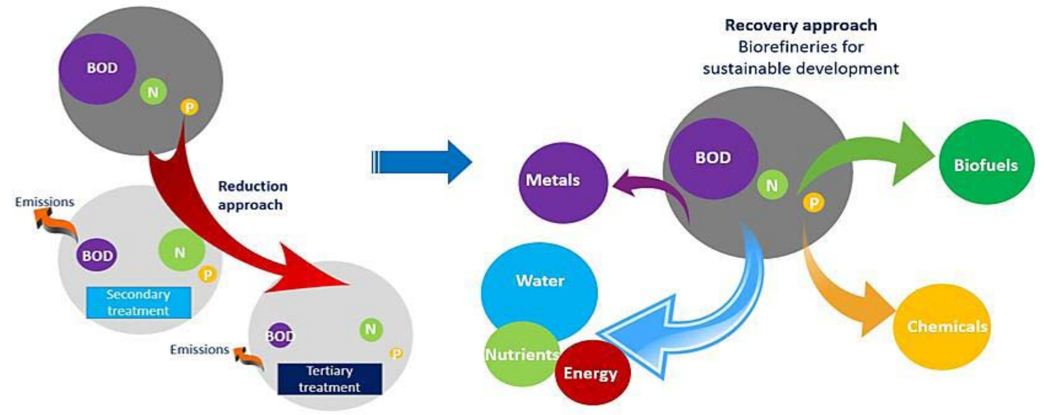

Figure 1: Wastewater treatment plants-from reduction approach to recovery approach.

Table 1: Advanced water treatment technologies for water reuse applications.

Process	Dissolved organic matter	Trace organics	TDS	Bacteria & Protozoa	Viruses
Microfiltration				X	
Ultrafiltration				X	X
Nanofiltration	X	X	X	X	X
Reverse osmosis	X	X	X	X	X
Electrodialysis			X		
Granular Activated Carbon (GAC)	X	X			
Ion exchange		X	X		
Advanced oxidation processes		X		X	X
Ultraviolet disinfection				X	X

nutrients in excess quantities can cause environmental issues especially related to aquatic environments. Nutrients are removed in wastewater treatment plants whereas same nutrients are required in other applications often purchased at high costs. The anthropogenic fixation of N from the atmosphere, nearly exclusively from the carbon-intense Haber-Bosch process, surpassed nature's fixation of N several years ago. The massive release of bio available N to the environment has been referred to as "global fertilization." While much P also is released into the environment, the global issue related to P is that the world is running out of high-phosphate deposits that are readily mined to feed the global appetite for P [15]. In view of these concerns, nutrient removal from wastewater is not a choice any more. Moreover, wastewater treatment plants must recover nutrients rather than remove them.

Struvite production is a well-known process for many wastewater treatment operations especially for nutrient rich wastewater streams from agricultural, farming and dairy industries [16,17]. Nitrogen and phosphorus can be recovered together through struvite formation. This can be achieved at multiple locations in a wastewater treatment plant such as the waste activated sludge stream, and anaerobic digester effluents. Sludge may be dewatered and incinerated to recover phosphorous. Further, as discussed earlier, nutrients can be recycled by embedding them into new lipid-rich biomass produced in the integrated processes. Biorefiney concepts can be developed to recovered nutrients by employing a variety of microbial and bioelectrochemical systems.

Water Scenario

Water is the most essential commodity for sustainable development. Due to population growth and rapid industrialization, many regions of the world are seeking the option of reusing wastewater effluents for non-potable applications [18,19]. The end use application determines the level of treatment required and the desired water quality. There are several technologies suitable for reclaiming treated wastewater for beneficial uses. These include membrane (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, and electrodialysis) technologies, adsorption (ion exchange, Granular Activated Carbon-GAC) technologies and other physico-chemical processes such as advanced oxidation processes including ultraviolet disinfection, ozonation, Fenton reaction and photocatalytic reactions [20]. The level of treatment in terms of pollutant removal capabilities are shown in Table 1. Advanced oxidations processes are implemented to remove the dissolved organic carbon and other emerging contaminants of concern [20,21]. These technologies are feasible in many applications due to high costs.

Future Needs

More aggressive research is needed to develop a holistic solution for wastewater treatment plants. Biorefinery concepts should be pursued where feasible to maximize the benefits of resource recovery and sustainable production. Novel processes such as anammox and other integrated processes should be given priority in development especially through granule-based treatment for smaller footprint and higher efficiencies. Water reuse technologies should focus on developing efficient solutions for removing emerging pollutants of concern such as endocrine disrupting chemicals and pharmaceutical and personal care products. Developments of appropriate integration and process optimization schemes and evaluation tools are necessary to maximize the operational benefits of the future wastewater treatment operations. Plant operators and managers play an important role in identifying the path forward for sustainable wastewater treatment. They must be educated and prepared to cope up with the increasing demands and challenging trends in their profession while they journey towards the water and resource recovery facilities of the future.

References

1. Sheik AR, Muller EE, Wilmes P. A hundred years of activated sludge: time for a rethink. Front Microbiology. 2014; 5: 47.
2. Gude VG. Energy positive wastewater treatment and sludge management. Edorium J Waste Manag. 2015; 1: 10-15.
3. Gude VG. Energy and water autarky of wastewater treatment and power generation systems. Renewable and Sustainable Energy Reviews. 2015; 45: 52-68.
4. WERF. State of the science in energy generation from wastewater.
5. McCarty PL, Bae J, Kim J. Domestic wastewater treatment as a net energy producer--can this be achieved? Environ Sci Technol. 2011; 45: 7100-7106.
6. Logan BE. Microbial fuel cells. Wiley Online Library. 2008.
7. Logan BE. Simultaneous wastewater treatment and biological electricity generation. Water Sci Technol. 2005; 52: 31-37.
8. Pham TH, Rabaey K, Aelterman P, Clauwaert P, De Schamphelaire L, Boon N, et al. Microbial Fuel Cells in Relation to Conventional Anaerobic Digestion Technology. Engineering in Life Sciences. 2006; 6: 285-292.
9. Kokabian B, Gude VG. Photosynthetic Microbial Desalination Cells (PMDCs) for clean energy, water and biomass production. Environmental Science Process Impacts. 2013; 15: 2178-2185.
10. Kokabian B, Gude VG. Role of membranes in bioelectrochemical systems. Membr Water Treat. 2015; 6: 53-75.
11. Pittman JK, Dean AP, Osundeko O. The Potential of Sustainable Algal Biofuel Production Using Wastewater Resources. Bioresour Technol. 2011; 102: 17-25.
12. Beal CM, Stillwell AS, King CW, Cohen SM, Berberoglu H, Bhattarai RP, et al. Energy return on investment for algal biofuel production coupled with wastewater treatment. Water Environ Res. 2012; 84: 692-710.
13. Siegrist H, Salzgeber D, Eugster J, Joss A. Anammox brings WWTP closer to energy autarky due to increased biogas production and reduced aeration energy for N-removal. Water Sci Technol. 2008; 57: 383-388.
14. Jetten MS, Horn SJ, van Loosdrecht MC. Towards a more sustainable municipal wastewater treatment system. Water Sci Technol. 1997; 35: 171-180.
15. Wahlberg EJ. Nutrient Recovery: Why It is Not an Option Anymore. Proceedings of the Water Environment Federation. 2014; 17: 3799-3805.
16. Booker NA, Priestley AJ, Fraser IH. Struvite Formation in Wastewater Treatment Plants: Opportunities for Nutrient Recovery. Environmental Technology. 1999; 20: 777-782.
17. Miles A, Ellis TG. Struvite precipitation potential for nutrient recovery from anaerobically treated wastes. Water Sci Technol. 2001; 43: 259-266.
18. Daigger GT. Evolving urban water and residuals management paradigms: Water reclamation and reuse, decentralization, and resource recovery. Water Environ Res. 2009; 81: 809-823.
19. Bolong N, Ismail AF, Salim MR, Matsuura T. A review of the effects of emerging contaminants in wastewater and options for their removal. Desalination. 2009; 239: 229-246.
20. Wintgens T, Salehi F, Hochstrat R, Melin T. Emerging contaminants and treatment options in water recycling for indirect potable use. Water Sci Technol. 2008; 57: 99-107.
21. Fast SA, Gude VG, Truax DD, Martin J, Magbanua BS. A Critical Evaluation of Advanced Oxidation Processes for Emerging Contaminants Removal. Environmental Processes. 2017; 4: 283-302.

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