Emerging Technologies in Waste Water Management

Allāhquan L. Tate

North Carolina A&T State University

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# Table of Contents

- **Introduction** ................................................................................................................................. 1
- **Objective** ........................................................................................................................................... 2
- **Summary** ............................................................................................................................................. 2
  - **Physical Chemical Processes** ........................................................................................................ 3
    - **BluePRO™** ................................................................................................................................. 3
  - **Phosphorous Recovery** .................................................................................................................. 4
  - **Compressible Media Filtration** ...................................................................................................... 4
  - **Reverse Osmosis** .......................................................................................................................... 4
  - **Biological Processes** ..................................................................................................................... 5
    - **Bioaugmentation** .......................................................................................................................... 5
    - **Nitritation and Denitritation** ....................................................................................................... 6
- **Conclusion** .......................................................................................................................................... 6
- **References** .......................................................................................................................................... 7
INTRODUCTION

According to research conducted by the United States Centers for Disease Control and Prevention (USCDC\(^1\)), there is a direct relationship between diseases and the amount and types of water that is consumed. The Earth’s surface may be covered in two-thirds of water, the majority of that water is not potable\(^2\). There are more people in the vast regions of the world that do not have access to clean drinking water than those who can turn on a faucet and have drinkable tap water spout out into a glass. This is where engineering designs for environmental systems plays such an integral role.

In the recent uproar of environmental concern, wastewater treatment has been at the front of every environmentalist’s priority lists. Water is an essential substance for living systems as it allows the transport of nutrients and waste products in living organisms. If that water is contaminated and not properly treated, then the organism drinking it is at risk of whatever diseases are in the water. Since the turn of the 21\(^{st}\) century, there have been advances in wastewater treatment technologies. As most recent as 2007, some of the developments were adsorption and even carbon absorption processes. However, in the ladder part of the technological and innovative advancements, now in 2013, there are numerous patents and designs emerging.

In this paper, an overview of emerging technologies for wastewater treatment will be explored. From new anaerobic processes to bioaugmentation, nitrification and denitrification process, and even new advances in solar drying of sewage sludge. This paper will deliver a great understanding of why engineering systems for environmental designs are important. It will also highlight what the Environmental Protection Agency (EPA\(^3\)) and other organizations are doing to lead the charge in meeting the challenge of keeping progress in wastewater pollution.
OBJECTIVE

The objective of this creative project is to gain an understanding from doing a research paper on a selected topic related to one’s major; find innovative designs and developments and explain them; and to present a professional, well-written paper.

SUMMARY

In 2008, there were 14,780 fully functioning and operating wastewater treatment plants in the United States. With the amendments to the Clean Water Act (CWA4) in 1972, municipal treatment plants have been designed to handle the increasing demand for control of the pollutants in waste water. These industrial treatment plants are specifically designed to remove these contaminants, but in 2008 nearly 37 percent of the facilities produced and discharged effluent at higher levels of treatment than allowed by the federal standards for secondary treatment in the Federal Water Pollution Control Act (known as the Clean Water Act). Later that year the EPA compiled a document entitled “Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management” EPA 832-R-06-006, in which the most recent advances and innovative techniques to treat water were presented. And then again in March of 2013, it was updated and added to make information available on the latest technologies of the last five years.

Figure 1.
Typical Process for Wastewater Treatment
PHYSICAL-CHEMICAL PROCESSES

The EPA defines physical and chemical treatment processes as technologies that do not include any biomass in the process to achieve the treatment objective. These processes usually include sedimentation, dissolved air flotation, and centrifugation to remove suspended solids, chemical precipitation, and air stripping to remove dissolved gases. Chemicals are used in wastewater treatment to create changes in the pollutants that increase the ability to remove them. As a result, chemical addition and physical processes usually cohesive to provide successful treatment.

There are numerous types of technologies that have been patented, established, and are emerging. Some of these emerging technologies include BluePRO™ reactive media filtration, phosphorous recovery, compressible media filtration, and reverse osmosis.

BluePRO™

BluePRO™ is a reactive filtration system that’s objective is to remove phosphorous from wastewater. This combines co-precipitation and adsorption to a reactive filter media in an upflow sand filter. This system is most suitable for small to medium size plants like towns of Hayden, Idaho or Westerly, Massachusetts in which the flow demand is about 4MGD per day. It is often seen as being similar to other advanced filtration processes that utilized iron addition but this includes adsorption medium.

Figure 2. Hayward BluePro Series 21" Sand Filter and Pump System
Phosphorous Recovery

Phosphorous recovery is an innovative nutrient removal system that’s objective is designed to recover phosphorous as a usable product. It combines precipitation with crystallization and this has been adapted by most large scale facilities. This process is implemented in the high phosphorous return stream of sludge liquor from dewatering than in the mainstream where the concentration of the phosphorous is greater. It is most practical and works best when coupled with the biological removal of phosphorous.

Compressible Media Filtration (CMF)

Compressible media filtration is a multifunction, passive, high-rate filtration system for wet and dry weather treatment applications. This type of filter can be used to produce a reusable effluent, increase the organic removal capacity of the facility or treatment plant, and/or reduce the power consumption, and treat excess wet-weather flow including biological treatment. This biofilter utilizes a cell matrix that is sized for the excess wet-weather flow and generally meets the CWA’s secondary treatment effluent requirements.

Reverse Osmosis

Reverse Osmosis is closely associated with nanofiltration in that they both are membrane processes that are used to remove recalcitrant compounds that otherwise contribute organic carbon, nitrogen, and phosphorous, to reduce total dissolved solids, and viruses. The pore sizes of the filter typically range from 0.0001-0.001 micrometers, and operate at a pressure of 125-300 pounds per square inch per gallon. In Figure 3, the treatment processes characteristics are displayed to gain a better understanding.

RO operates by high-pressure diffusion of solutes through the membrane. It removes priority organic pollutants as listed by the EPA, bacteria, viruses, and recalcitrant organics.
Recent research has showed that this type of filter does not consistently achieve total nitrogen levels less than the allowed 1.0 mg/L by the federal regulations.

BIOLOGICAL PROCESSES

The EPA defines biological treatment processes as systems that use microorganisms to degrade organic contaminants from wastewater. These methods are used for treating industrial and domestic waters by the conversion of dissolved and suspended substrates into biomass which is then separated and removed from the water. Biological processes are potentially merited as being more economically beneficial because the disposal/reuse methods of the biomass require pre-treatment which generally consists of digestion thickening and dehydration with conditioning to increase the solid concentration 20% to 40%, which in turn will reduce the content of the residuals. They are also preferred as they tend to be more cost effective in terms of energy consumption and energy use.

There are numerous biological processes that have begun to be used but none better than the biological nutrient removal systems. These systems involve modifications of biological treatment systems so that the microorganisms in these systems can more effectively convert
nitrate nitrogen into inert nitrogen gas. The processes that will be discussed will be bioaugmentation and nitritation and denitrification.

**Bioaugmentation**

The objective of this biological process is to increase treatment capacity by adding bacteria to the bioreactor or upstream of the treatment reactor. Most frequently, this process is used to enhance nitrification, thereby allowing more reactor volume to be used for phosphorous removal. Types are two types of Bioaugmentation processes. There are In-Pipe technology, Trickling Filter and Pushed activated Sludge (TF/PAS), Seeding from External Dispersed Growth Reactors (Chemical type), and In-Nitri®.

IN-Pipe is an approach that uses facultative microorganisms added to the sewer system upstream of the treatment facility. The goal is to supplement or modify the biofilm on the walls of the sewer pipe. Using bioaugmentation this way, the sewer is intended to become apart of the treatment process by reducing the organic loading to the WWTP. In-Piping using dosing units installed at strategic locations in the sewer system and resupplies them with concentrated stock.

![Figure 4. Trickling Filter/Pushed Activated Sludge Flow Diagram](image)
Figure 5. Trickling Seeding from External Dispersed Growth Flow Diagram

Figure 6. Inexpensive Nitrification Flow Diagram
Nitritation and Denitritation

This biological process is simply the removal of ammonia from high-strength streams. This process involves the oxidation of ammonia to nitrite in an aerobic environment. This process is similar to nitrification but nitritation stops the oxidation at nitrite and does not proceed from nitrite to nitrate. One of the most effective processes is the Single-Reactors High-Activity Ammonia removal Over Nitrite (SHARON), which is a chemostat process without biomass retention.

CONCLUSION

In conclusion, the need for new innovative engineering technologies in waste water treatment processes has begun to change and shape a bright future for the water treatment industry. With the EPA working to improve the quality of processes, and the different organizations inventing technologies that create cleaner and safer techniques and membranes, the water treatment industry is growing.
REFERENCES


