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The Use of Ozone in Hospital Wastewater Treatment

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Abstract. The wastewater produced in municipal and industrial sources is a desalted water which may be used in agriculture if purified and refined well. In many countries, the treated wastewater is reused for irrigation and aquaculture. The most important issue in using municipal wastewater for irrigation is to ensure about the efficiency of process of waste water disinfection to decrease pathogenic microorganisms. Ozonation is an environment friendly and advanced technology with high efficiency in decreasing viruses and parasites and can be an appropriate alternative for chlorination of wastewater. Hospital wastewater has complex and various compounds such as pathogenic factors and medical and toxic chemicals which are mainly disposed in cesspools or enter into the city swage system that lead to water resources pollution crisis. Therefore, the aim of this study is to examine the use of ozone in refining hospital wastewater.

Keywords: Ozonation, hospital wastewater, coagulants

Introduction

Limited water resources in Iran, the increase of water resources pollution resulted from household agriculture, and industrial wastewater can be considered as the main challenge of process of sustainable management of water resources of Iran (1). Conducting municipal and industrial wastewater to the rivers and seas and polluting them have made these environments intolerable for the aquatic animals, one of the sources of human food, and seriously threatens their lives. On the other hands, polluted water used for irrigating the agricultural products (2) is one of the main sources of spread and grow of different diseases and directly endangers health of human societies and imposes much life and financial losses to them. Fortunately, continuous efforts in this field has led to significant results and development of science and technology has enabled experts to take steps in wastewater treatment in the country (3). The wastewater produced in municipal and industrial sources is a desalted water which may be easily used in agriculture if purified and refined well. By using wastewater for agriculture, we can certainly cultivate more lands and, by producing agricultural products being totally food, obviate the social needs. In Asian countries, millions of people are dependent on reusing wastewater and food through aquaculture or agriculture. India, Malaysia and some countries of Southeast Asia have been probably the first to use wastewater in pisciculture (6-4). The daily amount of wastewater produced in China is more than 100 cubic meters 90% of which is used in agriculture and aquaculture, so China has the first rank in this field. In Malaysia, Vietnam, and Thailand, like China, wastewater is directly injected in the fish ponds and increases the production of fish. In India, wastewater is used for fertility of fish ponds. In Kuwait, the use of treated wastewater for irrigation of agricultural lands has been begun since 1956 and, now, more than the daily amount of 300000 cubic meters of treated wastewater is used for irrigation of agricultural lands in coastal cities. In Mexico, more than the amount of two million tons of agricultural products, with the value of 33 million dollars, has been produced by using raw sewage. In Iran, the produced wastewater has been given to the farmers as the right of water

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in some cities. In some cases, the wastewater is indirectly used in agriculture after being discharged in surface water (5-8).

The methods of complete wastewater treatment can certainly produce a treated water free of pathogens even for irrigation of food products or for injection to underground water. The existing common methods for removal of pollutions of wastewater are not able to provide qualitative standards of water parameters for its reuse or discharge to the environment. Therefore, the need for application of advanced treatment technology for decreasing main remaining parts in downstream of wastewater treatment plant of municipal wastewater is significant nowadays. Today, various technologies, as advanced treatment, are used for achieving high quality effluent such as membrane filtration, activated carbon filtration, and chemical oxidation processes including ozonation.

Hospital wastewater contains pharmaceutical wastes, microorganisms, antibiotic-resistant bacteria, heavy metals, radioactive element, toxic chemicals, hormones, and disinfectants wastes (1), and if they are discharged directly to cesspools or city swage system without preliminary treatment, there will potential environmental and health irreparable dangers (2). Water pollution by pharmaceutical and hospital wastes causes many problems and pollutes surface water resources and aquifers (3). Therefore, treatment of hospital wastewater before entering to the city swage system is of great importance (4). Coagulation process makes colloidal particles unstable by adding coagulants (3). Flocculation operation causes unstable particles to clump together into floc and the floc are then filtered as sediments (9). Ozone as the coagulant is injected to the process before coagulation and flocculation (11). The injection of ozone acts as a disinfectant in wastewater (12) and increases the flocculation of live cell mass.

Suarez et al (2009) examined pretreatment of hospital by coagulation and flocculation. Alum and chloroferric with dose of 0-200 mg/l were examined as coagulants, the result showed that Alum with a dose of 50 mg/l was the best coagulant (12). Another study on hospital wastewater treatment was conducted by Bok Lee et al (2009) by using coagulation and flocculation and the results showed the best coagulant. As PAC has an important role in using appropriate coagulant for forming floc and the speed of their formation and also in the removal of colloidal, the aim of this study is to evaluate all types of coagulants before and after ozonation for pretreatment of hospital wastewater.

Types of Processes of Water and Wastewater Treatment:

The processes of water and waste water treatment include (18): 1- Coagulation and flocculation process 2- absorption process 3- membrane process 4- ion exchange process 5- chemical oxidation process 6- biological process

1) Coagulation and Flocculation Process

Coagulation and flocculation process is one of the processes of wastewater treatment which is used to remove colloidal particles. Colloidal particles cause turbidity in water (17).

Management of injection of chemicals is one the best strategic correct methods of water treatment plant especially in the process of mixing and coagulation. Management of injection of coagulants is a global issue which is a standard for achieving low turbidity in each plant and includes determining the type of chemical, amount of injection, application method of materials, etc. (19).

1-1) Chemicals

Injection of appropriate chemical is a standard for optimizing the flocculation and sedimentation processes. There are three common chemicals used for raw water including coagulants, coagulant aids, and PH controller chemicals (20).

1-1 A) Coagulants:

Coagulants are those chemicals which are used to absorb turbidity and organic materials from raw water and remove bacteria, seaweeds, colors, iron oxide, manganese oxide, calcium carbonate, and clay. Metal salts and polymers are two types of the most common coagulants and alum (white alum) and chloroferric are the most common metal salts (21).

Note: in order to select coagulants, Standard Jar Test, which shows the relative effect of coagulants on raw water, is used.

Jar Test has been designed to show the effect of chemicals in wastewater treatment plant. This test is a general method for evaluation of coagulation, flocculation, and sedimentation in the plant. In fact, Jar Test is a small model of units of rapid mixing, coagulation, and sedimentation of the plant in which chemicals, especially alum, chloroferric, and polymers used to decrease the turbidity of water, are evaluated in lab scale (23).

Therefore, Jar Test is done for three reasons: 1- what type of coagulant is needed 2- whether coagulant is needed or not 3- how much coagulant is needed.

1-1 B) Coagulant Aids:

Coagulant aids are added to the input or simultaneous with coagulates to improve floc. Coagulate aids accelerate the process of sedimentation (sedimentation is done on the basis of two mechanism 1- diameter of materials 2- weights of materials) and decrease loading turbidity on filters (in most of water treatment plants, gravity sand filters are used. In commercial applications, coagulants along with pressure filters are also used) and consequently increase operating cycle of filters (24).

Coagulant aids include: 1- oxidizing agents 2- absorbent and weighting agents 3- active silica 4- poly electrolyte. Poly electrolytes are of three types: cationic, anionic, and nonionic. Poly electrolytes are used because of their bridging state (19).

1) Oxidizing Agents: oxidizing agents such as chlorine, chlorine dioxide, potassium manganite, and ozone are used when there are water-soluble organic matters in water and cause its turbidity and opacity.

An Explanation on Chlorine in Water and Wastewater Treatment

Chlorine is mostly used to disinfect drinking water. Chlorine and its derivatives such as sodium hypochlorite and chlorine dioxide are strong antiseptics and, if added to water in small amounts, remove bacteria and microorganisms rapidly. Chlorine not only controls growth of biological masses and seaweeds in distribution pipes and reservoirs but also helps to remove unpleasant smell and taste. Currently, using of chlorine as disinfection is the most common method in the world, including our country, because of its low price, germicidal power, and relatively well residual effect (21).

2) Absorbent and Weighting Agents: including (22) A- Bentonite clay which has high density, bleaching and absorption properties. B- Silica powder C- lime D- activated carbon. Activated carbon is used to remove

the residual chlorine in water, decrease and remove dissolved organic matters and radon gas. Uses of activated carbon are:

- When there are dissolved organic matters in water, activated carbon is used to remove them

- For treatment of industrial wastewaters when they cannot be biologically decomposed or if they are toxic

- Activated carbon has a catalytic role and is used for dechlorination of water.

1-1 C) PH and Alkalinity Controller Chemicals:

Optimization of PH make the metal coagulants to form stronger floc and consequently turbidity is removed better. Water should have an appropriate amount of alkalinity to form iron chloride or alum floc. For example the limits of PH of alum is 2 to 7 and of chloroferric is 3.5 to 6.5 and more than 8.5 (18).

Determining the amount of Injection

While the type of coagulant seriously depends on the features of input of the plant. Its amount is determined by examining the output. Coagulation examinations can be performed in two batch and continuous forms. Batch examination provides the indexes of selecting determination of the amount of injection at a point of inflow. But continuous examination can monitor coagulate process and adjust leading factors (17).

Note: chemical and biological reactions in water treatment, such as coagulation and flocculation, etc. take place in reservoirs, ponds, and containers called reactors: batch and continuous reactors.

Coagulation and Turbidity Monitoring Examinations

There are three main examination for determining conditions of coagulation and monitoring turbidity including Jar Test, Zeta Potential, and Pilot Filter.

Jar Test has been explained above.

Zeta Potential

In this method, charge of particles are measured by some electrodes. Examination of charge of particles, relates electrode output to electrical potential between water and ions around colloidal particles.

Pilot Filters

Pilot filters continuously measure water quality. They provide direct and precise measures of expected turbidity of output water and cause to remove the intermediate stage of lab tests for prediction of implementation of real scale. Pilot filters determine the sufficiency of the amount of injection of chemicals and are operated by manual or automatic mechanisms.

Injection Points

The injection point of any chemical can strongly effect the output. The best state is that chemicals can be injected into the water in seven points of treatment process so that the leader can find the best injection point by testing. These points are (19): before rapid mixing, during rapid mixing, before flocculation, before sedimentation, before filtration, after filtration, before washing filters.

2) Absorption Process

This process is for treatment of long-term decomposable solutes, non-biodegradable or toxic materials in sand filters and takes place in coagulation. This process includes two physical and chemical states. Absorption processes have physical state under electrovalence and attraction forces (20).

3) Membrane Process:

In membrane process, water or water components move through the membrane under the propulsion of three factors of 1- pressure 2- electrical potential 3- concentration gradient. Nowadays, membrane technology is used in water and wastewater treatment industries in a very large scale due to its low destructive impact on the environment and its low maintenance and operation costs. Soluble, suspended and biological pollutions of water and wastewater are removed by membrane process (24).

Reverse osmosis technology is based on the water penetration or osmosis through semi-permeable membrane that has the ability to pass pure water from one side to the other side; therefore, bacteria, dissolved salts, and organic and inorganic substances are separated from the water due to inability to pass the membrane.

Reverse osmosis system is the only technology that has the ability to separate all types of dissolved and suspended substances and results in achieving a water with appropriate quality for drinking and industrial uses.

Note) in case we have a diluted solution and a concentrated solution with a semi-permeable membrane in between, normally, water moves from the diluted solution to the concentrated one so that the solution reaches equilibrium. But if we put a little pressure on the concentrated solution to prevent water from coming into the concentrated solution, this pressure is called osmotic pressure, and if increase the pressure so that the water moves from the concentrated solution to the diluted one, this pressure is called reverse osmotic pressure (21).

4) Ion Exchange Process

Ion exchange process is one of the forms of absorption phenomena in which fluid phase is placed in contact with absorbent solid phase. During this contact some parts of fluid phase are absorbed to the solid phase and separate from the fluid. The ion exchange process is a reversible process in which the foreign ions existing in water are absorbed to the operating groups on the polymer network (solid phase); thus, the water free of any ionic impurities is achieved (18).

The scope of application of ion exchange technology is: production of water deionized water, remove hard water, removal of foreign cations from water, remove alkalinity, restore water in metal industry, removal of nitrate and sulfate, etc.

5)Chemical Oxidation Process

When there are toxic, long-term decomposable, and non-biodegradable materials in the wastewater, chemical oxidation process is used. In this process, a harmful chemical is combined with an oxidizer (such as potassium permanganate, chlorine, ozone, hydrogen peroxide) and then the chemical is oxidized and changed into sediment and the oxidizer is reducted, it means that a harmful chemical is changed into a less harmful or harmless one by chemical oxidation (18).

Conclusion:

Ozonation can be a better alternative for chlorination for municipal wastewater treatment to be used in agriculture and irrigation. For effective disinfection, the injected ozone must be more than the urgent need of wastewater for ozone. By Ozonation with a dose of 4 mg/l, standards of wastewater for agriculture can be achieved. For better results and complete treatment of microorganisms more doses is needed. In order to remove fecal bacteria, ozone Ct is about 1 mg/l in a minute that shows ozone high power for decreasing these microorganisms. For decreasing the amount of COD significantly, wastewater needs ozone doses of 7 mg/l and contact time of 15 minutes. Ozonation of municipal wastewater causes the increase of oxygen and decrease of color and smell in addition to the complete removal of microorganisms and organic materials decrease, therefore, the appearance of wastewater is more acceptable for irrigation and especially by decreasing turbidity of wastewater, minimizes the clogging problems of nozzles and watersheds in drip and sprinkler irrigation.

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