Chapter

Correlation between Air Quality and Wastewater Pollution

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Abstract

Recently, air pollution is a universal problematic concern which adversely affects global warming and more importantly human body systems. This chapter focuses on the importance of air quality, and indicates the negative effects of emissions originated from both municipal and industrial wastewaters to atmosphere. More importantly, the improvements in wastewater treatment plants to eliminate the crisis of emissions on environment and human health is also clarified. Urbanization and distribution of industrials in urban areas influence the air pollution via releasing pollutants and contaminants to environment. The pollutant emissions from wastewaters are volatile organic compounds, Greenhouse gases and other inorganic pollutants (heavy metals) which are causes to many reactions through atmosphere, then products detriment whole environment and living organisms including human. Moreover, contaminants are also released into air from influents of municipal wastewaters and they are considered as the main resources of most threatened infections in human and other animals. As conclusion, because of the persistently development urbanization and industrialization as the wastewater pollutant sources, the environmental technology regarding wastewater treatments must depend on prevention of emissions to air before thinking on cost and good quality effluents.

Keywords: air pollution, municipal wastewater, pollutant emission, infectious agents, industrial wastes, promised techniques

1. Introduction

The world recognizes air pollution as detrimental issue that significantly affects public health. There has been intensive studies and documentation of the effects of air pollution around the world [1, 2]. Sustainable development in any society provides a good living standard for the individuals. Also, these include social progress and equality, environmental protection, conservation of natural resources, and stable economic growth [3]. Industrial and transportation emissions and their burden in regional and global harm on health, climate and vegetation have been well studied in last few decades [4].

Health effects due to air pollution are a big concern for the World Health Organization. Air pollution does not only cause toxicological effects on human health, it has also significantly degraded the environment in the last years [5, 6]. Now a day, wastewater treatment plants (WWTPs) are definitely known as one of the most crises on air quality and availability of gases, chemical pollutants and biological contaminants in environment directly resourced from sewage wastewaters [7].

Moreover, municipal wastewater drastically increased, and due to household waste contents and draining to trunk cannels close to the urban areas, they adversely affect human health rather than environmental damage.

Water pollution is a problematic on humanity and the aquatic life, and increase catalyzes climatic changes [8]. For instance, various human activities as well as the release of greenhouse gases by industries greatly contributes to global warming, planet temperature enhancement, and lowering of atmospheric air quality.

Sustainability of environment among different societies is importantly developed as an initiation of living standard improvement for individuals. And It aimed to solve the challenges faced to environment, economy and society) without effects on human and environment in the future. Sustainability is also important to progression and equality of social, environmental safety, preservation of natural resources and economic growth [3].

The main contributors of air pollution and their cooperativeness cause to increase risks on air quality. For instance, With the growth of population, there is also a growth in demand for gas, oil, and other energy sources. This has also increased the number of refineries and petroleum wastewater treatment plants [9]. The pollutants are mostly chemicals which present in items used by individuals, chemicals containing preservative compounds, dyes, hydrocarbons, proteins as nutrients, etc. In last few decades, the demand on synthetic chemical products increased and products easily delivered to homes, due to advertisement and evolution in lifestyle such as; internet availability and easily contact in society. On the other hand, more urbanization around the world leads to increase wastes per individuals, however, this is different among various countries while still considered as one of the most reasons of developed more and more liquid and soil wastes (municipal wastewater).

Fortunately, along all society wastewater treatment plants (WWTPs), purification seems to be familiar and properly applicable to remediate municipal and industrial wastes and there are good understandings in this aspect. However, the wastewater treatment systems are variously performed within different society, while the all of them are targeted for one reason of improvement air quality and human health. Thus, all organization including WHO and governments hardly work to be far from wastewater emission impacts and improvement of air quality.

This chapter is aimed to better understanding in adverse impacts of wastewater effluents on air quality via emission process which is directly and indirectly affects human health via respiratory and skin diseases. It is also aimed to keep air emission in line level in recent technologies, however the risks associated with exposure to emissions from WWTPs are uncertain and require more research, stronger regulatory frameworks and safer design consideration.

2. Wastewater pollutants emitted to air

Generally, the presence of high concentrations of pollutants in atmosphere are results from unsustainable regional policy and lack of affordable green technology transfer [10]. There are different pollutants and contaminants emissions, the diversity of chemical pollutants leads to classify emissions according to their etiological agent within different types of wastewaters. The design of constructed sewage channels also affects the emission rate into the atmosphere. Open wastewaters are more efficiently exhaust emissions than close box or underground constructed wastewaters, as a result of abiotic effects which leads to worm the water and stimulate more volatilize and release. The followings are the air pollutants which are also originated from wastewaters effluents and easily releasable:

2.1 Hydrocarbons

Hydrocarbon pollutants are defined as one of the great serious emissions that effects all life forms [11]. Aliphatic and aromatic hydrocarbons are released into the air from industrial outlets rother than solid wastes which are directly emitted into the air, particularly from petroleum industries [12]. Recently, in developed countries industrial wastes undergo several processes of purification such as; conversion, separation and treatment, while during processing hydrocarbon emission persistently occur and adversely affect air quality. Despite of the above occurrence of emission, transportation of refined or purified products through tanks and pipelines can also leakage to water bodies and additional hydrocarbon emission occurs through wastewater treatment plants [12]. According to Aljuboury et al., the effluents/outlets from petroleum industries containing pollutant products with easily emission [13]. Therefore, auxiliary emissions arise when volatile organic compounds are stripped off from the contaminated wastewater in aeration basins, drains, and ponds which are all considered as indirect emissions [12]. The pollution via hydrocarbons sometimes due to the accidents during over sea transportations, when crude oil and gasses leak and release on the surface of water body. Finally, these pollutants directly and indirectly reach human, animals and plants and adversely affect them [12].

2.2 Volatile compounds

Volatile compounds are chemical substances; they have low boiling points and are immediately released into the air after contact. The concentration and identity of volatile compounds in wastewater and their emission to air varies according to the wastewater resources, transport system, characteristics of the employed treatment plant and the weather (physical) conditions. The aeration process and mechanism involved in oxygen diffusion in wastewater treatment plant states transfer characteristics between air and wastewater. And several organic substances in wastewater are either adsorbed, biodegraded or volatilized [14].

The emission of volatile organics from municipal wastewater plants is the main problem for wastewater treatment systems. Different types of pollutants (solvents and chemicals) that originated from municipal wastewater considered as a major source of VOCs. They are also presence in gaseous forms and leads bad odors/toxicity, they are crises on natural environment and air pollution resulted in the availability of VOCs [15]. In addition, VOCs also released during the composting of different organic wastes [16]. According to He and his colleagues, volatile organic compounds are also released during bio-drying of municipal solid waste. Biodegradation of wastes causes the production of these compounds in composting sites. During the process of biological decomposition, a huge quantity of VOCs is released from the organic matrix as well [17]. Because of the close relationship between wastewater streams and landfills and high occurrence of leaking from solid wastes of landfills to water streams, it is important to discuss the efficiency of landfills in VOCs emissions. Gases are also produced in landfills when household chemical products are vaporized in the landfill sites [18]. Landfills in many countries closed to municipal wastewaters, therefore solid wastes from this site certainly drained to wastewaters. The abandoned landfills had volatile organic compounds over the permissible limits, and their release to wastewater and directly for atmosphere is estimated over the permissible levels. Benzene, toluene, ethylbenzene, and xylene were the major volatile organic compounds detected in the air [19].

Petroleum as highly pollutant in environment contains high concentration of VOCs. Controlling the release of volatile organic compounds into the air is a big

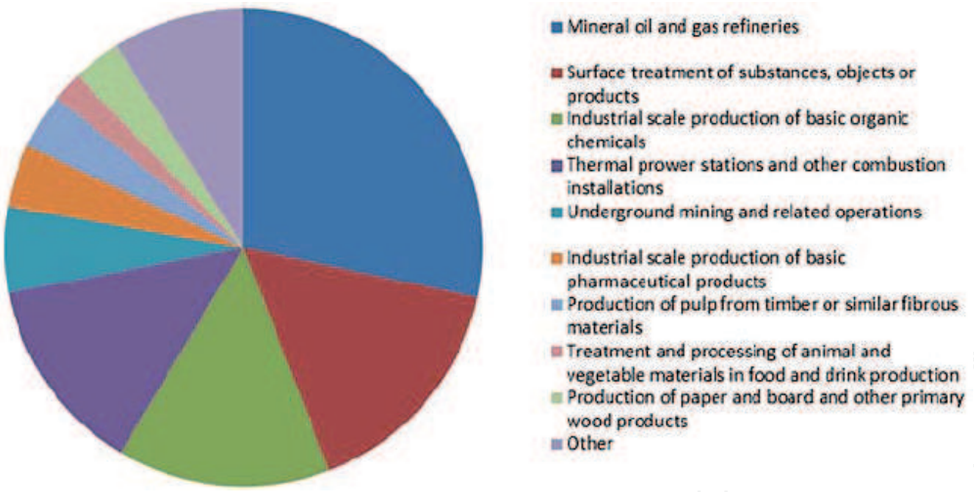

Figure 1.
Non-methane volatile organic compound emission shares from European industrial facilities in 2012 [22].

challenge for petroleum and the oil refining industries [12]. Malakar and Saha (2015) had concluded that, High concentrations of VOCs are derived from streams effluents of petroleum industries and refineries [20]. Moreover, the applicable fossil fuels in treatment plants (desalination) are noticed to release about 16,000 tons of VOCs. Thus, there may be a constitution fuel for desalination process [21]. Despite the anthropogenic or municipal wastes, emissions of VOCs from industrial wastes are also defined, and different industrial sectors are presented in the **Figure 1**.

2.3 Greenhouse gases

Municipal wastewater treatment plants are known to be one of the minor sources of greenhouse gases that are distributed in the atmosphere. Generally, there are three major sources of greenhouse gases (methane, carbon dioxide, and nitrous oxide) which are easily and frequently emitted into space, they are also found to cause indirect emissions from energy generation process [23, 24]. Aerobic biological treatment plants produce very large amounts of greenhouse gases as they require a large amount of energy to carry out various processes. The quantities of the resulted gasses depend on the influent of the wastewater, off-site treatments, and treatment processes in WWTPs [25]. According to United State Environmental Protection Agency (USEPA) in 2018, the three gasses emission in United States of America were ~ 81%, 10% and 7% for CO_2, methane and N_2O, respectively. With the remained 3% of emitted Fluorinated gases [26] (**Figure 2**).

Effect of wastewater treatments coming out of refineries and petrochemical industries is definitely problematic to environment and human health. Nevertheless, they are also known to cause large-scale emission of greenhouse gases into the atmosphere. According to Li et al., (2016), in United States of America around 0.40% of the total greenhouse gasses are emitted by wastewater treatment plants of refineries and petroleum industries [27]. Logistical pollutants which are frequently rely on fossil fuel consumption are considered as main reason of CO_2 and GHG emissions, and they are classified as significant contributor which affects environmental sustainability [28, 29].

2.4 Airborne microbial contaminants

Another critical issue that negatively affect air quality is the availability of microorganisms in atmosphere termed as microbial air pollution. The emission of

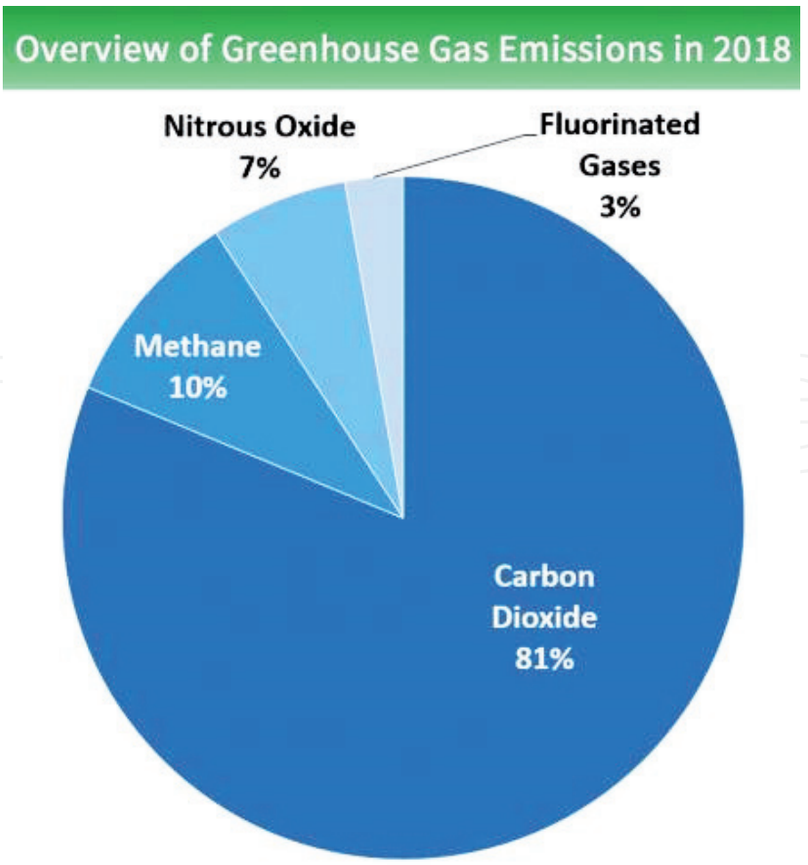

Figure 2.
Gas emission in 2018 in US (EPA).

bio-aerosols from wastewater to environment resulted from pollution of main sewage streams by human excreta (urine and feces) which containing a lot of microorganisms specifically bacteria (gram negative bacteria) [30]. The most common bacterial types released from municipal wastewaters are mostly include mesophilic pathogenic bacteria and psychrophiles, among them; *S. aureus*, Coliform bacteria, *Pseudomonas fluorescens* [31]. *Salmonella* sp., *Shigella* sp., *Pseudomonas aeruginosa*, *Clostridium perfringens*, *Bacillus anthracis*, *Listeria monocytogenes*, *Vibrio cholerae*, *Mycobacterium tuberculosis*, *Streptococcus faecalis*, *Proteus vulgaris* [32]. It is worthy to note that, many pathogenic microorganisms died and removed, while still some of them can survive in sewage sludge for the period of months [33]. Wastewater treatment plants are also known to release aerosols into the atmosphere and cause health issues to people working with the plants and living in the surrounding areas. The droplets from WWTPs documented to carry ten to thousand times more bacteria into the atmosphere than the sources of water pollution. The release and emission of microorganisms mainly depend on the temperature, wind velocity, humidity, smog, and other factors. Importantly, the available humidity triggers microorganism's proliferation, as it eliminates the solar efficiency to eradicate microorganisms [34]. The presence and absence of microorganisms in wastewater also related to the quality and climate of the site, even in purified wastewaters depend on the employed method of purification [35]. During purification processes, the microorganisms can get atmosphere via aerosols, particularly when the wastewater undergo aeration process by using air diffuser and biological bioreactor chamber [36].

The basic nutrients in wastewater (N, C and P) directly affects microbial life, due to this, their availability in wastewaters and any other sites leads to increase microbial activity. Furthermore, the presence of abundant microbial community in environment commonly sensed around the world, particularly in highly polluted

zones. Microorganisms either contaminate atmosphere by themselves or involved in degradation of chemical compositions and finally a part of produced pollutants in the form of gasses (Volatile compounds) emitted into the air.

2.5 Nitrogen oxides and sulfur oxides

There are various processes that take place in the wastewater treatment plants. These processes lead to the production of oxides of sulfur and oxides of nitrogen. Nitrous oxide emission from wastewaters is known as a problematic contaminant which needs to be addressed. During this several years, dramatic increase of N2O was noticed. However, N2O is threatened but the emitted value is less than other chemical pollutants [37]. Particularly, the design of the sewers and their operational conditions potently facilitate N_2O emission into surrounded environment. Domestic wastewater which is originated from household activities by human also known to contain high concentrations of different nitrogen forms rother than phosphor and other chemical pollutants. The plants which take more efforts in nitrogen removal emit a less amount of nitrous oxide into the air [37]. The released nitrous oxide in atmosphere interact with other VOCs to make products such as tropospheric ozone [38]. The flux of atmospheric GHGs directly increases with the input nutrients, and it is also different from one type of wastewater to another one [23]. For instance, N_2O emissions are related to nitrification and denitrification processes which is triggered by some particular microorganisms. Denitrification of NO_3 and NO_2 as a result of metabolism of Nitrobacter more N_2O emitted into the air (**Figure 3**).

Combustion of fuel to run these plants also leads to the large-scale production of oxides of sulfur and nitrogen [10]. Continuously, sulfur dioxide (SO_2) emission is a detrimental issue in many developing countries, especially from influents of coal fired power plants and the coal industries. It is a pollutant that is directly emitted from the source and released into air, unlike tropospheric ozone which is indirectly produced from combination of chemical pollutants in atmosphere. The consumption of coal in human activities in form of wood, dung and crop residues for domestic energy at home also contributes to ambient SO_2 concentrations and adversely affect the children and adults who are exposed to high levels of this pollutant [39]. Sulfur oxide may create acidic forms of sulfuric and sulfurous as a result of presence vaporized water, then acid rain precipitation occurs [40]. On the other hand, the precipitated acid rain causes disturbance fresh water and vegetation on earth. Both nitrogen oxides and sulfur dioxide considered as the biggest sources of pollutants from desalination plants for wastewaters [41]. Desalination plants are known as producers of NOx and SOx with values about 60,000 and 200,000 tons per year, respectively [21].

2.6 Heavy metals

Heavy metals are listed at the top of inorganic pollutant with wide range of negative effects on organisms, plants, and human [42]. Heavy metals released into the environment via different routes such as industries, domestic, mining activities, agricultural activities and etc. [43]. Heavy metals are not degradable and accumulated in living systems [44]. Thus, air pollution by heavy metals is considerable even at low concentrations and the long-term cumulative is threatened for human health [45].

The effects on human health and the environment from exposure to the three most common heavy metal pollutants (mercury, lead and cadmium) include:

Mercury is known as one of the toxic forms of metals that can harm different systems from human body (the brain, heart, kidneys and lungs), and lowering immune response against foreign objects of all ages. Moreover, childhoods affected in central nervous system and causes to less able to think and learn [46]. The mercury cycle is particularly important for understanding how it can reach atmosphere from different sources within wastewater, specifically illustrates how this metal that can be methylated. There are many compounds which are widely used in industrial processes and big demand on this metal observed around the world. Inorganic mercury that concentrated at the bottom muds of the water was methylated by anaerobic bacteria of the genus Desulfovibrio (in **Figure 4** below).

Collaboration among each of atmosphere, apical aerobic water layer and anaerobic sediment is seriously affecting Hg cycle. Some anaerobic microorganisms at the bottom, can convert free mercury to methylated forms that can be transported to water and the atmosphere such as Desulfovibrio as an example of bacteria. Methylated mercury processed through biomagnification. The produced volatile elemental mercury (HgO) is easily distributed into upper oxygenated water body

Figure 3.
Nitrous oxide emission to atmosphere from wastewater treatment plants.

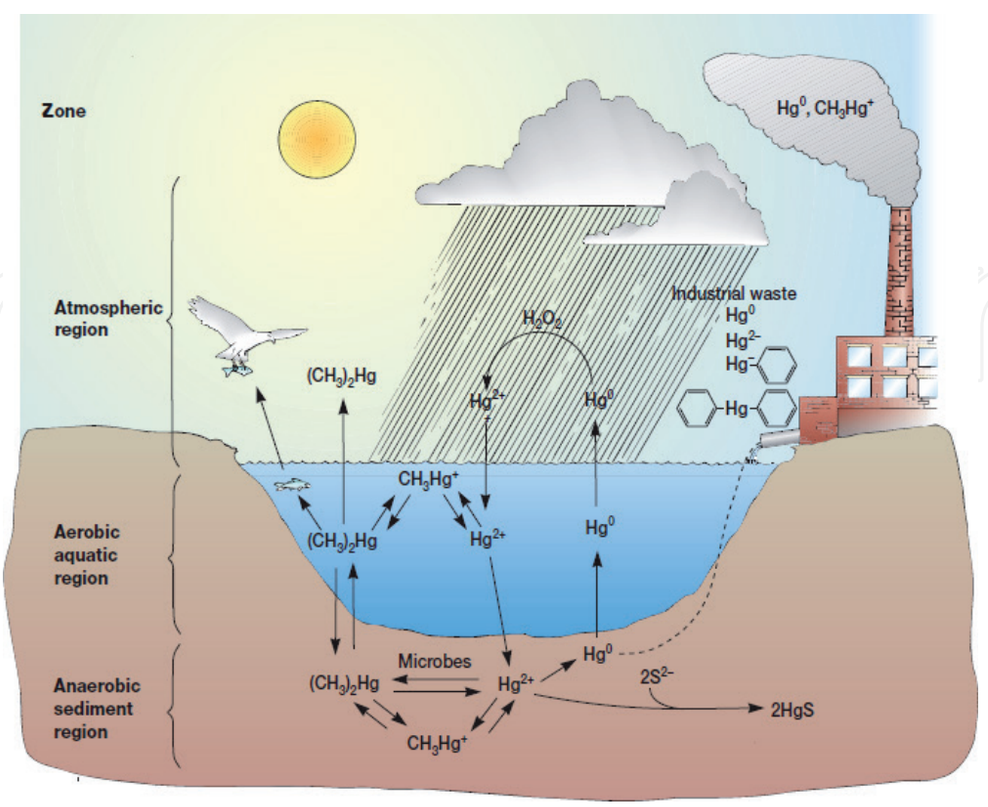

Figure 4.
The mercury cycle.

and even atmosphere, and then to waters and the atmosphere. Ionic mercury can react with sulfide in anaerobic sediment and resulted in less soluble HgS.

The produced methylated mercury is characterized as volatile and lipid soluble, and the mercury concentrations increased in the food chain (by the process of bio-magnification) and also increased in atmosphere. For example, the directly emitted Hg into atmosphere is evaluated by 2500 tons/year, which is accounting for about 31% of the overall emissions [47].

Lead as a non-essential heavy metal causes to late neuro-developmental in children, even at trace levels of exposure. Other effects include cardiovascular, renal, gastrointestinal, hematological and reproductive effects. Children six years old and under are most at risk. Currently, the thresholds of Pb are unknown. Lead frequently reaches human, animal and plant bodies and accumulates as a toxic substance [48].

Cadmium as a toxic metal and it is presence can make many problematic issues including: pulmonary irritation, kidney disease and cancer, bone weakness and prostate. Among the Cd sources, food and cigarette smoke are the common which easily exposure for the general population. About 90% of Cd exposure from dairy sources into the environment and to people who are not smoking.

Cadmium (Cd) as a toxic metal to plants, animals and microorganism. It may cause lowering growth rate of plants and many serious diseases for human as a result Cd accumulation, mainly in the kidney and liver of vertebrates and in aquatic invertebrates and algae. Severe toxic effects on fish, birds and other animals may include death or fetal malformations [49].

The availability of Pb, Hg and Cd was studied by Du and his team in Heilongjiang City- China, samples were collected from 27 WWTPs with intervals monthly during 2015. And the results ensured the removal of heavy metals from wastewater is highly affective as they released to environment which finally adversely affects humanity [7].

3. Effects of polluted air on human health

According to the investigation published by the World Health Organization, the number of died people was estimated by 7 million as a result of air pollution exposure in 2012 [50]. This number indicates one out of eight total global deaths and confirming that air pollution is the world's largest health risk. Thus, the mortality rate much higher than that caused by malaria and AIDS. Air pollution is not only the concern of one nation or country, while it is increasing daily along with increase urbanization and industrialization. The universal cooperation is the only solution to overcome this critical issue (air pollution) which has crisis on humanity, and air is a natural resource without geopolitical boundaries [4]. Individuals are affected by different types of emissions directly and indirectly via inhalation of pollutants and climate change (for instance; when solar radiation gets trapped by gaseous and suspended particulate matters in atmospheric layers, respectively [51].

Many people exposed to these emissions and microorganisms may show unhealthy signs of respiratory problems and digestive system issues [34]. Bio-aerosols are known to contain various types of microorganisms that can cause disorders of the respiratory system, digestive system, and skin. Bio-aerosols also affect the quality of air in the surrounding. Moreover, it was found that domestic sewage containing animal and human excreta contains the highest amounts of microorganisms. They are usually treated and released by municipal wastewater plants which cause various micro-organisms to enter the atmosphere [52]. The spread of microorganisms in atmosphere depends on the weather and season [53].

Chronic obstructive pulmonary disease, acute lower respiratory illness, ischemic heart disease and lung cancer have been contributed to most air pollution related cases and even deaths. Inhalation of fine particles from air (particulate matter) and produced ozone are detected as the origin of those diseases [50]. All studies agreed on the presence of correlation between green technology improvement and environmentally sustainable. For instance, Khan and his colleagues (2020) have prepared two important hypotheses, which are "(1. Greater environmental performance reduces the health expenditure) and (Country environmental performance has a positive correlation with economic growth)" [28].

4. How to keep air pollution in line from wastewater emissions?

The previous wastewater treatment plants were afforded only to obtain large purified effluents from wastewaters and cost-effective protocol, while no consideration about the emissions as a result of biological reactions. Now a day, global attempts considered to increase environmental sustainability which is derived from greenhouse gasses (GHGs), organic and inorganic compounds that directly emitted into the atmosphere and air quality disruption.

To minimize GHG emissions from wastewater treatment plants, the following recommendations can improve the practical systems with lowering gasses emissions. To minimize N_2O emissions, biological wastewater treatment plants should be operated at high solid retention times (SRT) to preserve low ammonia and nitrite concentrations. Moreover, big bioreactors are suggested to dispose of systems able to large volume loading buffer and to decrease the risk of transient oxygen depletion. The emissions N_2O can be reduced (if nitrous oxide stripping by aeration is limited since microorganisms would have more time to consume it) [19]. On the other hand, application of anammox processes can be used to remove ammonia. On the basis of the metabolism of anammox bacteria, N_2O is not directly produced [54], and therefore, it is considered as a promised process to emission N_2O in the WWTPs as a constitute of the conventional nitrification–denitrification processes.

Methane (CH_4) emissions can be reduced into a minimum value by properly covering sludge tank and sludge disposal tanks, to prevent gas leakages and emitted CH4 captured by hoods which could be undergo through burning with excess biogas in a torch [51]. Methane gas usually produced within WWTP itself and from it is sources. Methane is mainly undergo oxidation by approximately 80% in the activated sludge tanks, which could be exploited to further decline methane emissions to atmosphere from WWTPs [55].

The SRT as a promised invention applied to the biological reactor which triggers GHG emissions to atmosphere. The activated sludge system, especially when SRT value seems to be high, improves biomass endogenous respiration, which stimulates the COD oxidization to CO_2 and reduces the produced sludge. The lower sludge production indicates CH4 decline, thus any reduction of CO_2 release correlated to its combustion [56].

5. Conclusions

Air quality is not less important than any pandemic diseases throughout the world, due to uncontrolled emissions from anthropogenic wastes. The reports indicated that wastewaters are considered as one of the detrimental sources of pollutants in environment specifically within atmosphere. And the emissions from wastewater to air directly increase with urbanization and industrialization, which

are known as the main sources of wastewater pollution. Any additions of VOCs and GHGs in air directly and indirectly harm environment and human health. The priority of wastewater treatment plant systems must be changed from cost effective and good effluent quality to emission prevention then follow other aspects.

Conflict of interest

It is my pleasure to do further studies on environmental technologies, particularly bioremediation, phytoremediation and air quality in advance laboratories. Hope to get offers from different parts of the world to do whatever I want in my specialization.

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