A STUDY OF BIOAEROSOLS CONCENTRATION IN THE HOSPITAL WASTEWATER TREATMENT (ACTIVATED SLUDGE)

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ABSTRACT

Most wastewater treatment systems used in hospitals produces activated sludge, which causes bioaerosols, bacterial and fungi in the surrounding areas and causes problems in health in workers and surrounding residents.

This study concentrated on the bioaerosols in the wastewater treatment plant and in the area of office buildings. This study in wastewater treatment plants compared the surface aerator with the diffuse aerator and also studied upwind areas in comparison with downwind areas. The samples of aerosols were collected by using an aerosol monitor 8533 model DRX Dusttracx and collecting examples of bacteria and fungi by using an air samples Microflow 90 for collecting examples in 4 hospitals, with 100 samples. The results showed that the concentrations of bacteria and fungi in the office buildings and areas around the wastewater treatment plant were different (p-value < 0.0 5). However, the concentrations of aerosols in the office building were less than in the area around the wastewater treatment plant but there was not a significant difference. The concentrations of aerosols and fungi on the surface aerator and the diffuse aerator were different (p-value < 0.05). The concentrations of bacteria of the surface aerators and the diffused aerators were not different. The concentrations of aerosols, bacteria and fungi in the upwind areas and the downwind areas also did not show any differences.

In the area around the wastewater treatment plant, there were bacteria and fungi that presented more than in the area of the office buildings. The wastewater treatment plant, which had the diffuse aerators, showed the highest of increase in aerosols and fungi. Wind direction in the upwind area and the downwind area did not present effects on the concentrations of bioaerosols, this may be due to the fact that the area in the wastewater treatment plant was limited and there were more high buildings than in the surrounding wastewater treatment areas.

KEY WORDS: AEROSOLS/ BIOAEROSOLS/ ACTIVATED SLUDGE /WASTEWARTER TREATMENT /HOSPITAL

90 pages

การศึกษาปริมาณไบโอแอโรซอล บริเวณบ่อบำบัดน้ำเสีย แบบแอกทิเวเต็ดสลัดจ์ ในโรงพยาบาลของกรุงเทพมหานคร

A STUDY OF BIOAEROSOLS CONCENTRATION IN THE HOSPITAL WASTEWATER TREATMENT (ACTIVATED SLUDGE)

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บทคัดย่อ

ในโรงพยาบาลนิยมใช้ระบบบำบัดน้ำเสีย แบบแอกทิเวเต็ดสลัดจ์ (Activated Sludge) ก่อให้เกิดไบโอแอโรซอล แบคทีเรีย และเชื้อรา บริเวณโดยรอบระบบบำบัดน้ำเสีย และพื้นที่ใกล้เคียง ก่อให้เกิดปัญหาสุขภาพอนามัยต่อคนงาน และผู้พักอาศัยโดยรอบ

การศึกษาครั้งนี้สนใจที่จะศึกษาปริมาณไบโอแอโรซอล แบคทีเรีย และเชื้อรา บริเวณรอบระบบบำบัดน้ำเสีย และในอาคารสำนักงานที่ผู้ควบคุมระบบทำงาน ศึกษาระหว่างระบบบำบัดน้ำเสียที่ใช้เครื่องเติมอากาศบนผิวน้ำเปรียบเทียบกับเครื่องเติมอากาศแบบใต้น้ำ และศึกษาบริเวณที่อยู่เหนือลม และใต้ลมโดยทำการเก็บตัวอย่างแอโรซอลด้วยใช้เครื่องวัดปริมาณอนุภาคขนาดเล็ก ยี่ห้อ Dusttracx DRX Aerosol Monitor รุ่น 8533 และการเก็บตัวอย่างเชื้อแบคทีเรีย และเชื้อรา ด้วยเครื่องเก็บตัวอย่างอากาศ ยี่ห้อ Microflow 90 โดยทำการเก็บตัวอย่างในโรงพยาบาล 4 แห่งๆละ 100 ตัวอย่าง ผลการศึกษา พบว่า ปริมาณแบคทีเรีย และปริมาณเชื้อรา ภายในอาคารสำนักงาน มีความแตกต่างกันอย่างมีนัยสำคัญ กับบริเวณบ่อบำบัดน้ำเสีย (p-value < 0.05) แต่ปริมาณแอโรซอลภายในอาคารสำนักงาน มีปริมาณน้อยกว่าบริเวณบ่อบำบัดน้ำเสีย แต่ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ปริมาณแอโรซอล และปริมาณเชื้อรา ของบ่อบำบัดน้ำเสียที่ใช้เครื่องเติมอากาศบนผิวน้ำ มีความแตกต่างกันอย่างมีนัยสำคัญกับบ่อบำบัดน้ำเสียที่ใช้เครื่องเติมอากาศแบบใต้น้ำ (p-value < 0.05) แต่ปริมาณแบคทีเรียไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ปริมาณแอโรซอล แบคทีเรีย และเชื้อราของบริเวณที่อยู่เหนือลม และใต้ลมของระบบบำบัดน้ำเสีย ไม่มีความแตกต่างกัน

ดังนั้นบริเวณรอบระบบบำบัดน้ำเสียมีแบคทีเรีย และเชื้อรามากกว่าภายในอาคารสำนักงาน เครื่องเติมอากาศแบบใต้น้ำมีผลให้ปริมาณแอโรซอล และเชื้อราเพิ่มขึ้น ส่วนทิศทางเหนือลม และใต้ลมไม่มีผลต่อปริมาณแอโรซอล แบคทีเรีย และเชื้อรา เนื่องจากบริเวณบ่อบำบัดน้ำเสียเป็นพื้นที่จำกัด มีอาคารสูงกว่าระบบบำบัดน้ำเสียโดยรอบ ทำให้เกิดกระแสลมแปรปรวน

90 หน้า

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CHAPTER I
INTRODUCTION

1.1 Background and rationale

Community wastewater is generated from the daily activities of the people living in the community and occupations include wastewater from homes, hotels, hospitals, schools, shops, office buildings etc. Wastewater is very dirty because it has the component form of organic compounds (Organic Matters). The volume of wastewater in the building types as shown in Table 1 (1). From the table it shows that the hospital was one of the buildings cause wastewater volume up to 800 liters per bed per day. In Bangkok has 111 hospitals and a place to keep patients overnight of 25,596 beds (2). The large hospitals have wastewater from other parts such as clean container of medical equipment, clean rooms or classrooms, medical etc. The amount of wastewater is a lot and properties of the waste water from the hospital are close to the community wastewater but there is dirty higher and have pathogen contamination. Most of which are pathogenic (Pathogenic Microorganism) (3). Therefore, the Ministry of Natural Resources And Environment has determined that hospitals must control the sewerage of buildings are required to treat wastewater before it is released to the public water.

A wastewater treatment plant that used in hospitals affiliated with the Ministry of Public Health, including Oxidation Ditch, Stabilization Pond and Anaerobic Filter, Activated Sludge and Aerated Lagoon (2). And a study on wastewater treatment plant commonly used in hospitals around the Chao Phraya River basin area consists Bangkok, Samut Prakan, Nonthaburi, Ayutthaya, Ang Thong, Sing Buri, Pathum Thani and Nakhon Sawan found that wastewater treatment plants are the most used to be Activated Sludge and followed by Oxidation Ditch, Pond Aeration and Anaerobic Filter, respectively (4). Studies of Katsivela E et al, 2007 found that the primary stage of wastewater treatment plant has quantity of aerosols over the secondary and the tertiary stage of wastewater treatment plant (5). A study of the

Bauer H, et al, 2002 found that the arithmetic mean of the bacteria and fungi collected from activated sludge treatment plant has more than the other wastewater treatment plant (6). And Orsini M, et al, 2002, study of contamination of bacteria. And fungi in the air of hospital 's the wastewater treatment found that 90% of bacteria and fungi is 10%, which is the most common bacteria to be Gram negative bacilli and the types of the most common fungi are Aspergillus (7). In addition, Stellacci P et al, 2009, a study on the assessment of the harmful the use of biological models.They found that people live near the wastewater treatment plants for more than 300 meters there is a risk for the disease in 1000 to 5 people (8). Where the disease was found on the workers or people who live near the wastewater treatment plant is sewage worker's syndrome . Symptom is fever, fatigue (9). Studies of Smit LAM et al, 2005 found that health hazards are associated to the quantity of aerosols in the area of wastewater treatment plant. And the quantity of aerosols associated to the symptom of lower respiratory tract and skin symptoms significantly (10).

When 2011 there have been reports of illness of the hospital's wastewater treatment plant controller of affiliated Bangkok metropolitan. They have irritant of the skin (rash) and the symptom of respiratory tract so the importance cause to a study of bioaerosol concentration in the hospital wastewater treatment (Activated Sludge)

1.2 Objectives

1.2.1 General Objective

To study the differences of the concentrations of aerosols, bacteria and fungi in the workplace area of the wastewater treatment plant (Activated sludge).

1.2.2 Specific Objectives

1.2.2.1 To study the concentrations of aerosols, bacteria and fungi in in the workplace area of the wastewater treatment plant (Activated sludge).

1.2.2.2 To compare the concentrations of aerosols, bacteria and fungi between in the area of office buildings and in area around the wastewater treatment plant.

1.2.2.3 To compare the concentrations of aerosols, bacteria and fungi in the wastewater treatment plant used between the surface aerator and the diffused aerator.

1.2.2.4 To compare the concentrations of aerosols, bacteria and fungi between in upwind area and in downwind area at the wastewater treatment plant.

1.2.2.5 To study of type and concentrations of bacteria and fungi in the area of office buildings and in area around the wastewater treatment plant.

1.3 Hypothesis

1.3.1 The concentration of aerosols, bacteria, and fungi in the area of office buildings are difference from area around the wastewater treatment plant.

1.3.2 The concentration of aerosols, bacteria, and fungi of wastewater treatment plant used the surface aerator are the different diffused aerator.

1.3.3 The wind direction at the wastewater treatment plant relate the concentration of aerosol, bacteria, and fungi in workplace of the wastewater treatment.

1.4 Variables

1.4.1 Independent variables

1.4.1.1 Area is the area of in the area of office buildings, area around the wastewater treatment plant and the background area.

1.4.1.2 Type of aerator is the surface aerator and the diffused aerator.

1.4.1.3 The wind direction at the wastewater treatment plant.

1.4.2 Dependent variables

1.4.1.1 The concentration of aerosols.

1.4.1.2 The concentration of bacteria.

1.4.1.3 The concentration of fungi.

1.5 Scope of study and limitation

1.5.1 The influence loading mass is less than 1,000 cubic meters.

1.5.2 pH of wastewater 5-9.

1.5.3 BOD is more than 20 milligrams per liter.

1.6 Definition

1.6.1 Bioaerosols is aerosol size 1-10 micron, bacteria and fungi.

1.6.2 The area of office buildings is area in office building for the wastewater treatment controller does document work and there is air condition system.

1.6.3 Wastewater treatment plant is activated sludge system used in hospital wastewater treatment plant.

1.6.4 Area around wastewater treatment plant is area of the wastewater treatment controllers work in outdoor around wastewater treatment plant: the pretreatment tank, the aeration tank, the sedimentation tank, the downwind and the upwind of the wastewater treatment.

1.6.5 The surface aerator is the aerators installed and fill air at the surface of aerator tank.

1.6.6 The diffused aerators is the aerators installed and fill air at the under of aeration tank.

1.6.7 Wind direction is wind blow through the wastewater treatment plant by wind instruments (Aerovane).

1.6.8 Type of bacteria is Gram positive bacteria, Gram negative bacteria and Bacillus spp.

1.6.9 Type of fungi is Aspergillus niger, Aspergillus flavus, Fusarium spp. and Pennicillum spp.

1.6.10 The concentration of aerosols is the quantity of solid particle and liquid droplet diffusing in the air. In the study collect the aerosols size 1 -10 micron by TSI Dust Trax instrument and unit is mg/m^3.

1.6.11 The concentration of bacteria is the count of bacteria collected from the air in the area of office buildings and outdoor around the wastewater treatment plant by instrument is Micro Flow 90 and unit is CFU/m^3

1.6.12 The concentration of fungi is the count of fungi collected from the air in the area of office buildings and outdoor around the wastewater treatment plant by instrument is Micro Flow 90 and unit is CFU/m^3

1.7 Conceptual Framework

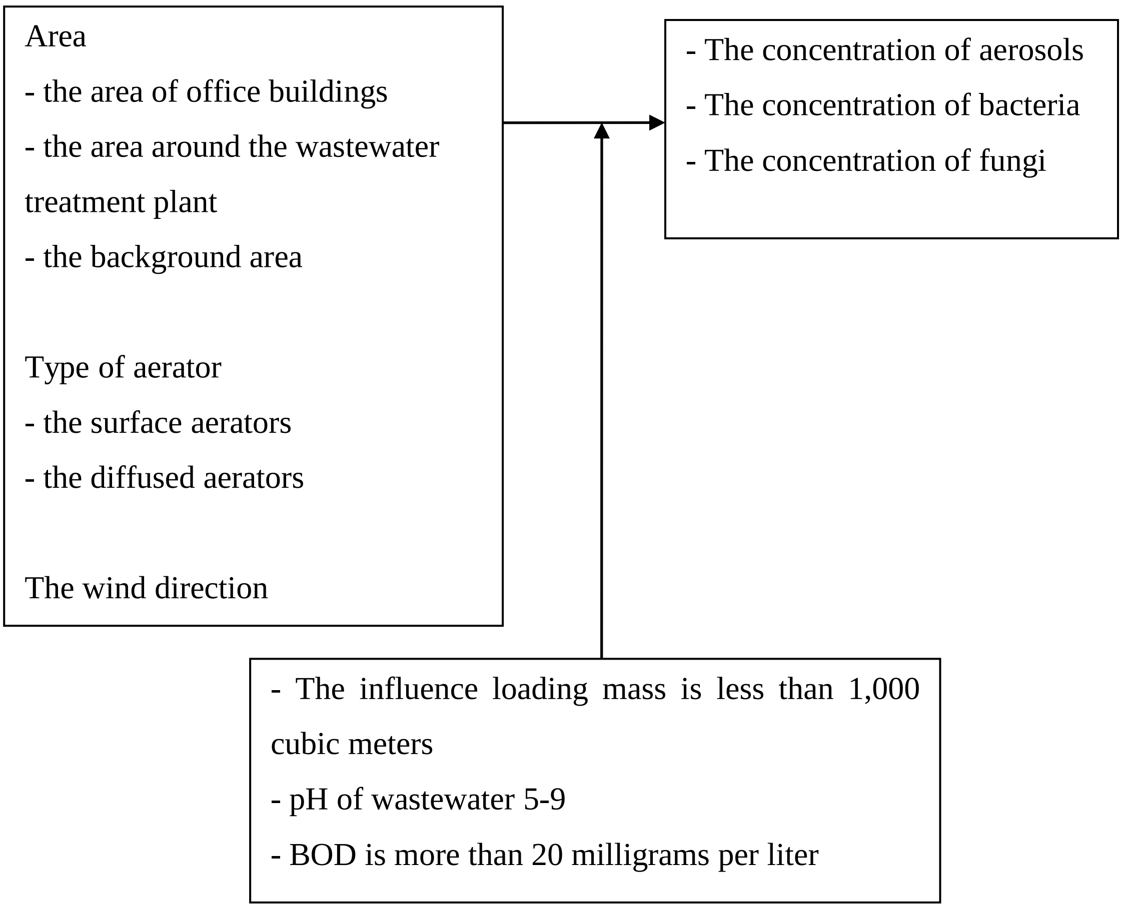

Figure 1.1 Conceptual framework

CHAPTER II
LITERATURE REVIEW

2.1 The quantity of wastewater in different type of building

PCD has been studied to assess the quantity of wastewater resulting from different types of building, the most of the quantity of wastewater is the hotel (1000 liters/ day/ room), the second is the hospital (800 liters /day / bed) and the last is the offices (3 liters /day /square meter) by the details showing the quantity of each type of building waste water in table 1 (1).

Table 2.1 The quantity of wastewater in different type of building (1).

Type of building	Unit	The quantity of wastewater liters /day - unit
Hotel	Room	1,000
Hospital	Bed	800
Condominium/House	Unit	500
Service location.	Room	400
Housing	People	180
Dormitory	Room	80
Market	square meter	70
Restaurant	square meter	25
Shopping malls	square meter	5
Office	square meter	3

2.2 Wastewater treatment plants in the hospitals

Wastewater treatment plants in the hospitals include oxidation ditch, stabilization pond, anaerobic filter, activated sludge and aerated lagoon. A study on wastewater treatment plant commonly used in hospitals around the Chao Phraya River basin area consists Bangkok, Samut Prakan, Nonthaburi, Ayutthaya, Ang Thong, Sing Buri, Pathum Thani and Nakhon Sawan found that wastewater treatment plants are the most used to be Activated Sludge and followed by Oxidation Ditch, Pond Aeration and Anaerobic Filter, respectively (4).

Activated Sludge is the most biological wastewater treatment system because there are more microorganism degrade organic compounds in wastewater. These microorganism are floating in the water of the aerator tank, which will add more quantity of microorganism in such a way that generally called the growth suspended. In aerator tanks has stirring system by the using a mechanical stir microorganism for floating inside the aerator tank at all times. Control microorganism in activated sludge system in as required by a separate system for clear water out of microorganism to the overfill tank. Settling tank is the concentration of water is very microorganism, which is too much microorganism may pump discharge from the bottom tanks, settling tanks or more direct aerator tank and microorganism is disposal and treatment. The characteristic of the activated sludge, as follows: (11).

2.2.1 Conventional process

Conventional Process is the process of aerator flow according to the same (Plug flow) which make up the BOD and the more concentration of microorganism in the water way. BOD should be consistent so it will be good and could not get them very toxic (12).

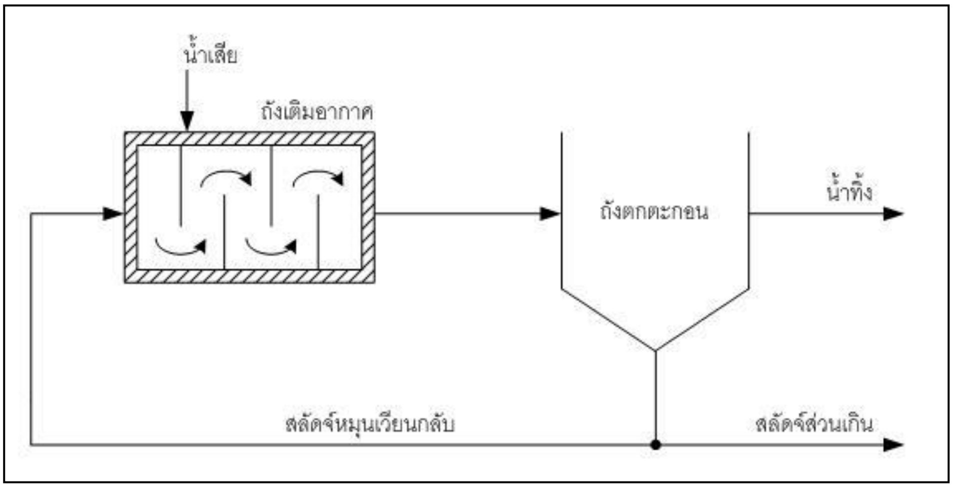

Figure 2.1 Conventional process (12)

2.2.2 The tapered aeration process

The Tapered Aeration Process is the process of aerator thank like conventional process but it will install the aerator in beginning of system. In the beginning of aerator tank will be install diffused aerator in the less distance and gradually increase the distance to the end of thank for oxygen demand to use. as well as the conventional process is BOD should be consistent so it will be good (13).

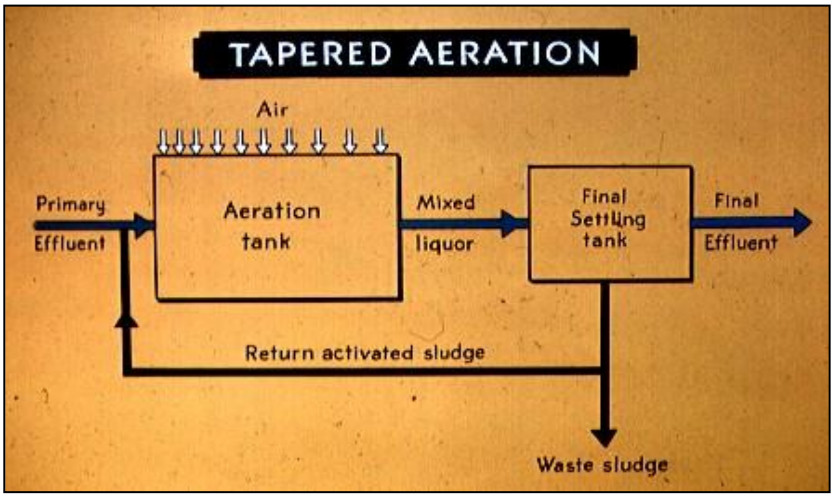

Figure 2.2 The tapered aeration process (13)

2.2.3 The Step Aeration Process

The processes that have been entered into the wastewater of several points along the length of the aerator tank for to efficiently treatment BOD volume irregular and receive more than the conventional suspension process and the tapered aeration process (11).

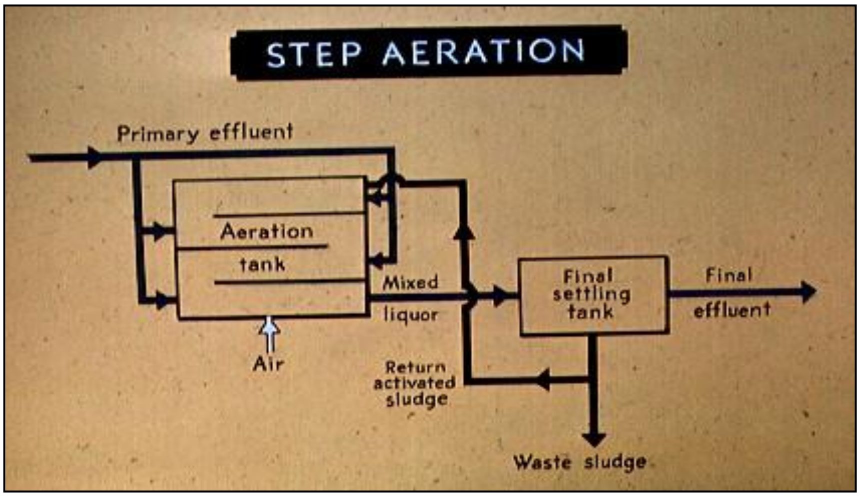

Figure 2.3 The step aeration process (11)

2.2.4 The completely mixed

The completely mixed is an aerator tank with stirring the violence done to mix completely. The intensity of any point in the tank is always equal to the inflow is excess quantity of BOD should at some time or the inflow of toxic. This system will help to mix well together, stirring, which have concentrations of BOD, or toxic substances in the tank drops. It is prevent the occurrence of concentrations of wastewater over unexpectedly. (Shock load) through the tank was found to be based on flow theory together (Plug Flow) are a better performance but the practice stirred up such differences are less so some don't the difference. This is because the treatment system control is an important factor than a tank (13).

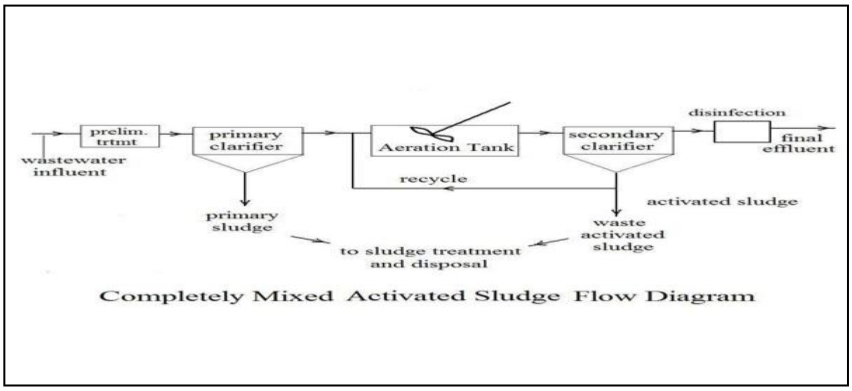

Figure 2.4 The completely mixed (13)

2.2.5 The extended aeration

The extended aeration is the process of a period of wastewater and sludge age more than others activated sludge, so the thank size will be much larger than the other system. But it has the advantage that it is easier to control the high performance system, which may not necessarily take sludge water disposal. Because in theory and then there will be no mass microorganism occurred, but in practice they often degrade the substance doesn't occur consistently so there is sludge discharge from the system. This system is most used in the less quantity wastewater, as high building, etc. (12).

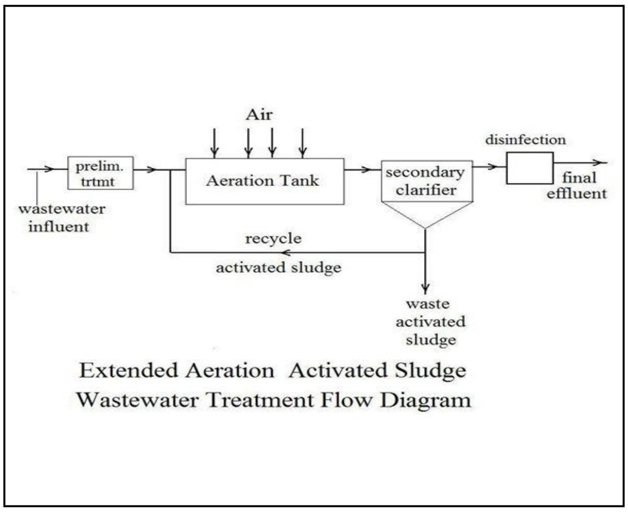

Figure 2.5 The extended aeration (12)

2.2.6 The sequencing batch reactor (SBR)

The sequencing batch reactor uses only a single aerator tank. It can serve as both a complement to degrade organic compounds and serves to separate sludge sedimentation tank with the same interior. This is a system that allows wastewater flow in the sludge's tank, which is filled the air. Afterwards, will stop fill the air causing the sedimentation which will get the clear water that leaves it out. The treatment process is finished, then apply a new set of incoming wastewater to continued. The aerator tanks may be 2 or more tanks to used alternately by without settling tank. This system can also eliminate nitrogen and phosphorus level one. Depending on various factors, such as characteristics of the wastewater control system, operation, etc., and also found that this system will prevent a problem settling. Sludge bulking problem is poor and prevent the occurrence of Foam concentrate tanks, so come out again. This system is, there will be a period of time that the microorganism in the air without causing microorganism types that cause Bulking Sludge and bubbles do not occur in this system (13).

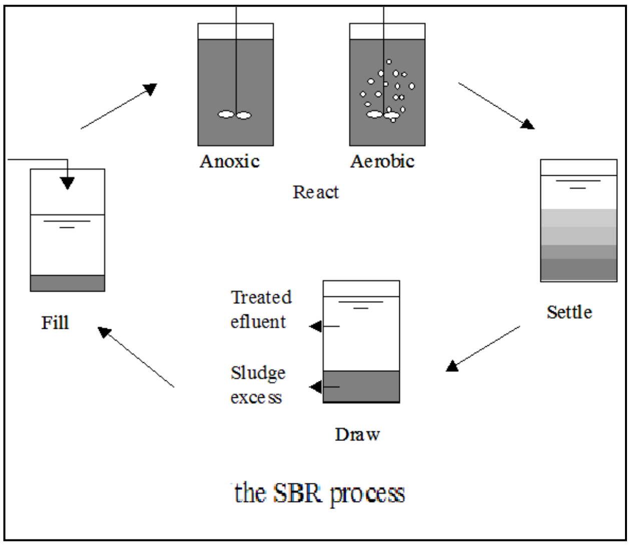

Figure 2.6 The sequencing batch reactor (SBR) (13)

2.2.7 The oxidation ditch

The oxidation ditch like the extended aeration process but it has the format of a tank ditch by a tank mixed complete. Water flow in tank ditch are approximately 0.25 to 0.35 m/s and a full time 24 hours or more and sludge age has a long time like the extended aeration process (11).

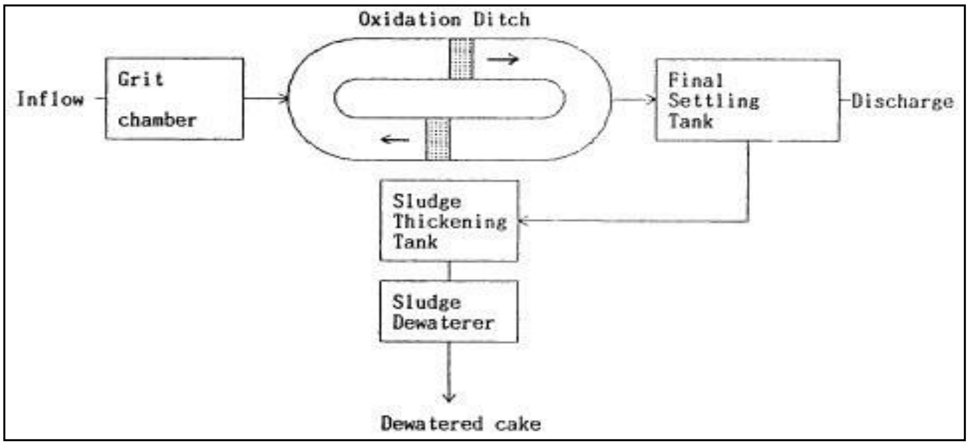

Figure 2.7 The oxidation ditch (11)

2.3 Aeration system

There are 2 major type of aeration systems are surface aeration system and diffuse aeration system.

2.3.1. Surface aeration system

It installs a motor that rotated the plate hit the water by the machine will be installed on the water surface that may adhere to the structure of the tank or floating on the surface of the water with a float (12).

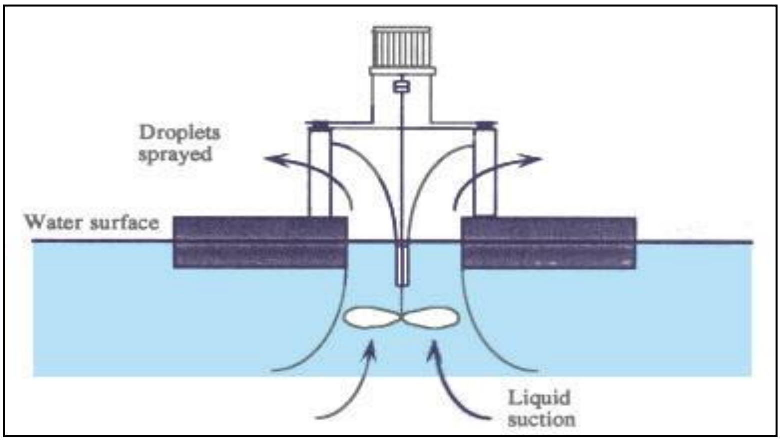

Figure 2.8 Surface Aeration System (12)

2.3.2. Diffused Aeration System

It is a system of aeration underwater by air compressor is blow the air into the supply pipe underwater (12).

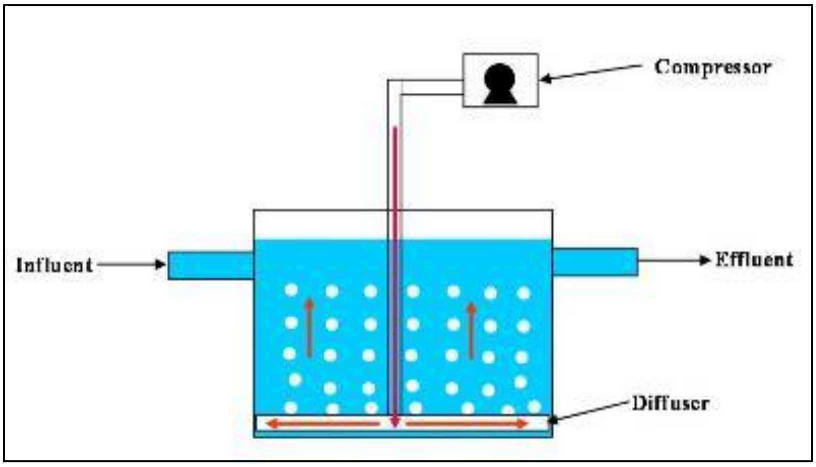

Figure 2.9 Diffused Aeration Systems (12)

2.4 Bioaerosols

Bioaerosols are creatures in the form of particles drift into the atmosphere. bioaerosols are from small viruses to large protozoa or algae float in the atmosphere, or possibly a dust or aerosols in atmosphere. The source of bioaerosols in natural sources for example, coughing, sneezing, skin peel out of the workers. The produce various chemical products for example, the particle distribution from wastewater treatment tanks, the cleaning system or plants. In a building has types of bioaerosols caused a turnover of air conditioner to spread and the distribution of bioaerosols when cleaning out the dust, and stuck with curtains (14).

2.5 Bacteria

Bacteria are prokaryotic organisms and unicellular microorganisms. It is quite small and widely in size 0.2 um in diameter to spiral 10.0 um long. Bacteria have three basic shapes such as rods, spirals and spherical. There are growing in human body and laboratory incubator at 37 °C. Viruses are smallest agent. It have size from the 250 nanometers (nm) of poxviruses to the 20 nm of parvoviruses and appear in several shapes (15).

Bacterial classification depends on the following characteristics.

- Morphology and arrangement
- Staining
- Cultural characteristics
- Biochemical reactions
- Antigenic structure
- Base composition of bacterial DNA

Morphology and staining of bacteria are the commonly used characteristics to classify bacteria.

Morphology of bacteria

When bacteria are visualized under light microscope, the following morphology are seen.

- Cocci (singular coccus): Round or oval bacteria measuring about 0.5-1.0 μmb in diameter. They are found in single, pairs, chains or clusters.

- Bacilli (singular bacillus): Stick-like bacteria with rounded, tepered, square or swollen ends; with a size measuring 1-10μm in length by 0.3-1.0 μm in width.
- Coccobacilli (singular coccobacillus): Short rods.
- Spiral: Spiral shaped bacteria with regular or irregular distance between twisting.

Bacteria are found in every habitat on Earth: soil, rock, oceans and even arctic snow. Some live in or on other organisms including plants and animals including humans. There are approximately 10 times as many bacterial cells as human cells in the human body. A lot of bacterial cells are found lining the digestive system. Some bacteria live in the soil or on dead plant where they play an important role in the cycling of nutrients. Some types of food spoilage and crop damage but others are incredibly useful in the production of fermented foods such as yoghurt and soy sauce. Relatively few bacteria are parasites or pathogens that cause disease in animals and plants.

Bacteria reproduce by binary fission in process the bacterium, which is a single cell, divides into two identical daughter cells. Binary fission begins when the DNA of the bacterium divides into two (replicates). The bacterial cell then elongates and splits into two daughter cells each with identical DNA to the parent cell. Each daughter cell is a clone of the parent cell (16).

2.6 Fungi

The fungi are a diverse group of eukaryotic microorganisms, with over 80,000 identifiable species. The majority of fungal species are composed of filamentous hyphae and often referred to as moulds, whereas the yeasts, which will be described later, are unicellular fungi. They can found in various inhabits, including air, soil, water and other living organisms as in vegetables, animals and humans. Generally a fungus is saprobes with complex life cycles usually involving spore formation. It grows well at normal room temperature (25°C) and usually growing on nutrient media (dextrose agar and potato dextrose agar). Molds are a major subdivision of fungi. It grows as long, tangled stands of cells that give rise to visible colonies (17).

Fungi are subdivided on the basis of their life cycles, the presence or structure of their fruiting body and the arrangement of and type of spores (reproductive or distributional cells) they produce.

The three major groups of fungi are:

- multicellular filamentous moulds.
- macroscopic filamentous fungi that form large fruiting bodies. Sometimes the group is referred to as 'mushrooms', but the mushroom is just the part of the fungus we see above ground which is also known as the fruiting body.
- single celled microscopic yeasts (18).

A mycosis is a fungal infection of animals, including humans. Mycoses are common and a variety of environmental and physiological conditions can contribute to the development of fungal diseases. When inhalation of fungal spores or localized colonization of the skin may initiate persistent infections; therefore, mycoses often start in the lungs or on the skin. People are at risk of fungal infections when they are taking strong antibiotics for a long period of time because antibiotics kill not only damaging bacteria, but healthy bacteria as well. This alters the balance of microorganisms in the mouth, vagina, intestines and other places in the body, and results in an overgrowth of fungus (19).

2.7 Aerosol

The aerosol particles are solid or liquid. Particles may be caused by difference distribution (dispersion) or condensation. An example of the explosion for example the grind, the scrub, the explosions. The condensation is caused a combination of molecules of substances to heating or cooling. Aerosol has size 1-100 micron (20).

2.8 Respiratory system

Respiratory system by anatomy contains the upper respiratory include nose, pharynx, larynx trachea, and part of bronchus. And the lower respiratory : bronchus, bronchiole and alveolar.

Respiratory system by particle size filter ability as follow:

Group 1 is the respiratory system ability filtrate the particles of size more than 10 microns to include the nose and throat.

Group 2 is the respiratory system ability filtrate the particles of size between 2-10 micron to include trachea.

Group 3 is the respiratory system ability filtrate the particles of size more than 2 micron into lung and alveolar (21).

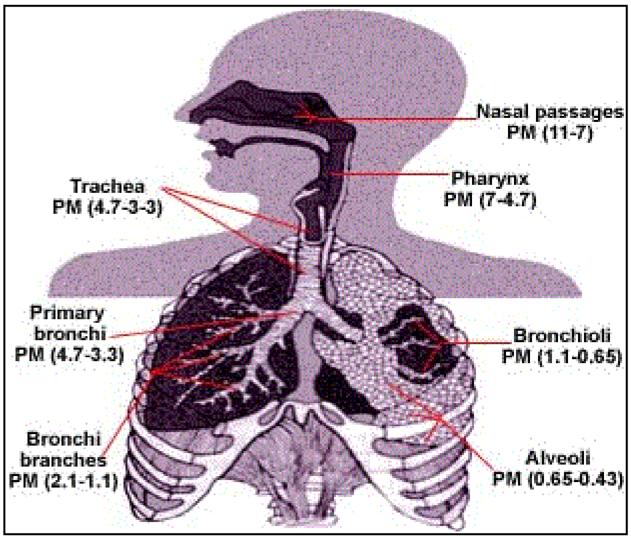

Figure 2.10 Respiratory system (21)

2.9 Defense mechanisms of the respiratory System

The respiratory system is defense mechanisms involves tiny, muscular, hair-like projections (cilia) on the cells in line the airways. The airways are covered by a liquid layer of mucus that is propelled by the cilia. These tiny muscles beat more than 1,000 times a minute, moving the mucus that lines the trachea upwards about 0.5 to 1 centimeter per minute. Particles and pathogens that are trapped on this mucus layer are coughed out or moved to the mouth and swallowed. Because of the requirements of gas exchange, alveoli are not protected by mucus and cilia mucus is too thick and would slow movement of oxygen and carbon dioxide. Instead, the body has another defense system. Mobile cells on the alveolar surface called phagocytes seek out deposited particles, bind to them, ingest them, kill any that are living, and digest them. The phagocytes in alveoli of the lungs are called alveolar macrophages. When the lungs are exposed to serious threats, additional white blood cells in the circulation, especially neutrophils, can be recruited to help ingest and kill pathogens (22).

2.10 Sewage worker's syndrome

The symptoms of worker with a wastewater treatment plant or any other type of waste treatment, exposure to bacteria and endotoxin from fragmented or evaporation of wastewater and chemical from bacteria or fungi digest organic compounds in waste treatment. There are the eye irritation, respiratory irritation, headache, conjunctivitis, fever, cold, cough, diarrhea, or abdominal pain or more symptoms associated with other symptoms (23).

2.11 Methods of collecting bioaerosols

Device of collect bioaerosols sample on principle as well as sample particles. It is separated bioaerosols from the air flow and particle traps, stored on or in the middle of a solid, liquid, or filter paper or agar. Commonly used technique is to store sample with impaction, filtration and trap with liquid in impingement then takes samples to analyses for concentration and type of bioaerosols (20).

2.11.1. The impaction method.

The impaction using the device sucked air through tiny channels which bioaerosols impact the agar plate and bioaerosols can growth in the agar plate and create a colony or treat on slide or adhesive tape to incubate or endoscopic and observation spore characteristics(20).

Figure 2.11 The impaction method (20)

2.11.2 The filtration method

The filtration use a filter paper for filtrate bioaerosols from the air which relies on the same general particle filtering mechanism. The filtration is the collision with tissue or filter paper fibers directly for adhere with filter paper because of inertia or passive from different electric charge and gravity then take filter paper to rinse or shake bioaerosols into solution and then solution dilution, as appropriate. Then put to cultivation on agar and colony count. The general use filter paper type membrane(20).

Figure 2.12 The Filtration method (20)

2.11.3. The liquid impinger method

The Liquid impinger method collect by sucking the air through a liquid impinger. Bioaerosols in the trap is liquid media or sterilized liquid. There are several kinds of bioaerosols that is widely used is peptone soluble in water, Betain soluble in water and then taken to the appropriate agar. In general liquid or media with bioaerosols will be dilution with sterile isotonic solution before taken cultivation on agar for colony density fitting (30 – 300 colony/plate) (20).

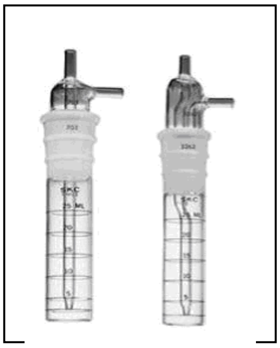

Figure 2.13 The Liquid impinger method (20)

2.11.4. The direct reading instruments

It includes tools to collect the examples and sample analysis in a particular tool, which can be read from the measuring directly and immediately, or at the time of the measurement. The effect of measuring may be in the form of screen reading devices, read the paper from the color change of the chemical on the gauge, or change from one color to another color etc. Tools to read the value directly is sometimes referred to as a tool to read the actual measured time value because data from the analysis and design processes. In this study, using the measurement name DustTrak DRX. Working principle: The work will start from the air sucked by the pump has a flow rate equal to 3 liters per minute into the ongoing detection room. Part of the air is divided into rooms before going to catch and pass the HEPA filters, and then injected back into the chamber around inflow. Inside, with light from a laser diode collimating lens which is passed to the cylindrical lenses to create some strips of light shines into the Chamber where the Interior of the Chamber has a curved mirror spherical gold coating, which acts in the light scattering and particles will be monitored by a photo detector. Signal processing of machine DustTrak DRX differs from conventional photometer the signal of four-diode will be split into two elements: a signal to light (photometric signal) and the pulse of single-particle (particle single pulses) (24).

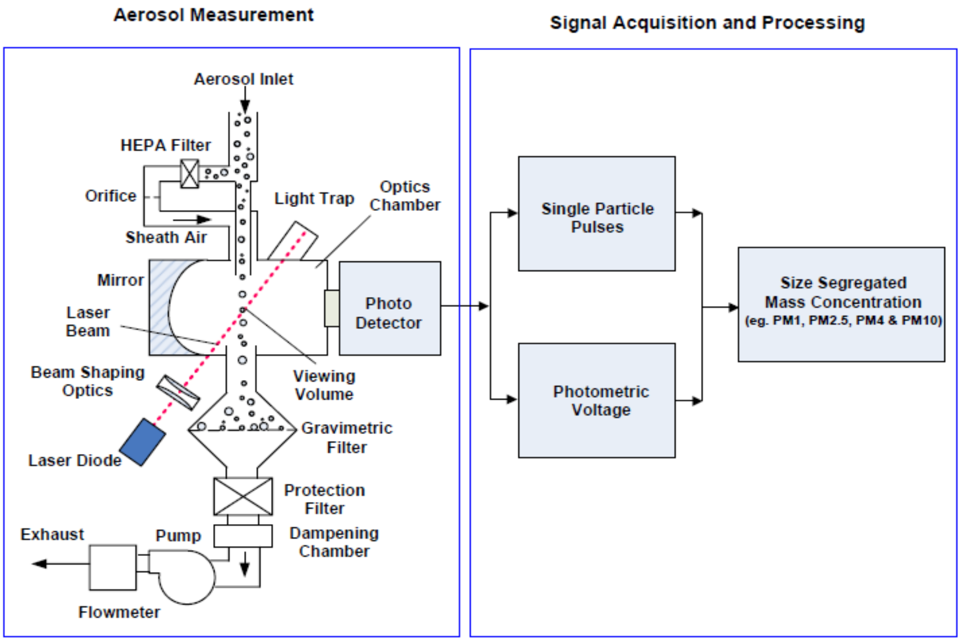

Figure 2.14 The direct reading instruments (24)

2.12 Literature cited

Katsivela E and Karra S. (2007) (5) studied about bioaerosols that release from wastewater treatment plant in the Mediterranean in the summer and study in May – July, at Chania, Greece wastewater treatment plant by collecting sample with Sampler MAS 100. Sample collected in the pretreatment pond, the first sedimentation pond, the aeration pond, the second sedimentation pond, the fill chlorine pond and the sediment processing. By collected bacteria, fungi and faecal coliform at the same time collect heat radiation, temperature, relative humidity and wind speed, The result found in tertiary of wastewater treatment was less than secondary wastewater treatment and secondary wastewater treatment was less than primary wastewater treatment (bacteria reduced, 97.4%, faecal coliform reduced 100%,and fungi reduced 95.8%) moreover found bacteria, faecal coliform and fungi in wastewater areas was lower than the control area (bacteria reduced 19.7% , faecal coliform reduced 99.4% and fungi reduced 84.2%) so the heat radiation and temperature affect the reduction of bioaerosols release from wastewater treatment plant.

Bauer H et al, (2002) (6) studied the bacteria and fungi in 2 differences the waste water treatment plant were the activated sludge and the fixed-film. Sample collection by using an air filter with a filter membrane, and cultivation to count the number of colonies were collected from the plant using the activated sludge wastewater treatment system with the arithmetic mean of the mesophilic bacteria was 17000 CFU/m^3. The arithmetic mean of the TSA-SB bacteria was 2100 CFU/m^3. The arithmetic mean of mesophilic fungi was 1700 CFU./m^3, and the arithmetic mean of the thermotolerant fungi was 45 CFU/m^3 and in the plant using fixed-film with the arithmetic mean of the mesophilic bacteria was 3000 CFU./m^3. The arithmetic mean of the TSA-SB bacteria was 730 CFU./m^3. The arithmetic mean of mesophilic fungi was 180 CFU./m^3, and the arithmetic mean of the thermotolerant fungi was 14 CFU/m^3. However, when compared concentration of bacteria and fungi and the water surface area were the ratio of the activated sludge wastewater treatment plant was 8.4 X 10^{11} and the fixed-film wastewater treatment plant was 4.9 X 10^9.

Orsini M et all. (2002) (7) studied about bioaerosols associated with hospital wastewater treatment plant by compared oral cavity isolates against isolates collected from aerosols surrounding the aeration basin. At increase distance ; 1 m, 4 m, and 15 m found that 61 % were gram negative bacteria, 29 % were gram positive bacteria and 10 % were fungi species. Comparison, isolates from the bioaerosols samples were not related to worker exposure.

Stellacci P et all. (2010) (8) studied about the development of hygienic conditions of the area around the plant. There was evaluation the occurrence of hazard from biological pollution by a quantitative microbial risk assessment (QMRA) of the wastewater treatment plant in Taranto, Italy, They assessed the impact on health that may occur to people who live nearby. They collected samples with Cryptosporidium (protozoa), Campylobacter (bacteria) and Rotavirus (virus) by GIADA recommend and make air models (a hybrid plume dispersed model), proposed by the environmental protection agency Italy for estimating the concentration of pathogen in the air. From this studied, a distance of 300 meters in the model around the wastewater treatment plant in order to bring that information to reduce the risk to public health that live nearby.

Fannin KF et al. (1985) (9) studied of viruses and bacteria in aerosols during the late summer and the middle of the rainy season in the suburbs of the United States. Both before and during the startup of the activated sludge wastewater treatment system. In before startup system found 5 types of bacteria are Klepseilla, Enterobacter, Aeromonas, Sallmonella, and during the aerator stopped found bacteria increased from the original 6 types are Escherichia, Citrobacter, Providencia, Pasteurella. In the study requires the location of each point more away from the aeration tank is less than 150 m, 150 – 250 meters and more than 250 meters in downwind and found the most concentration of bacteria in downwind and after the startup system found concentration of bacteria increases.

Smit LAM et all (2005) (10) studied A study about the relationship between endotoxin exposure and symptoms in a group of people working on the wastewater treatment plant by collected examples of endotoxin in the workspace and used the questionnaire collected information about the symptoms of a sample of 468 people from 67 wastewater treatment plant. The results that factors associated with lower respiratory syndrome (Lower respiratory, Skin symptoms, The symptoms are similar to flu, and systemic symptoms). They found increase incidence in workers exposed to endotoxin is greater than 50 EU/m3 and found a significant relationship between endotoxin exposure to abnormal symptoms of lower respiratory and skin irritation, the symptoms are similar to flu and systemic symptoms.

Brandi G et all. (2000) (25) studied The study estimates the effects of bioaerosols that released from 2 wastewater treatment plants where had the aerator different be a fine bubble diffuse air system and a mechanical agitation aerator. The collection used 3 types of sample storage (SAS, Six-Stages Andersen and Impinger) to study in the summer, found concentration of bacteria above the aerator tank was 2247 CFU/m^3 and concentration of bacteria in the downwind around 2 meters from the wastewater treatment systems was 1425 CFU/m^3. The study found that the quantity of wastewater are related to fragmentation of bioaerosols ($p < 0.5$) in addition, the increase of the concentration of bacteria is associated with increasing time in wastewater treatment ($p < 0.05$), however long-term study , found concentration of the fungi and bacteria in large quantities in every area of the wastewater treatment plant. In downwind found about 20-40% of the bacteria that collect samples was coliforms, enterococci, escherichia coli and staphylococci and found infections in the last stage of Andersen Six-Stages. It meaned that the infection is very small and can be passed through the lungs of humans and wastewater treatment plant, and the wastewater treatment plants use a fine bubble diffuse air system have concentration of bacteria and fungi is less than the wastewater treatment plants use a mechanical agitation aerator.

Pascual L at all. (2003) (26) studied about bioaerosols release from wastewater treatment plant by estimating the occurrence of bioaerosols and collect air samples with a 100 MAS impactor (MERK) in area of each step of wastewater treatment plant (the pretreatment pond, the sedimentation and removal pond, the aeration pond and removal sludge). The study survey each area of work and to collect the bacteria , fungi, total coliforms, Pseudomonas aeruginosa and Mycobacterium tuberculosis by analysis of Polymerase Chain Reaction method (PCR). The results found on the pretreatment pond and the sedimentation and removal pond were release of bioaerosols highest and concentrations of bioaerosols depending on wind speed and quantity of wastewater influence per day, and There was Pseudomonas aeruginosa in the pretreatment pond, the sedimentation and removal pond in small quantities but Mycobacterium tuberculosis wasn't found in the area of wastewater treatment systems.

Kruczalak K et all. (2004) (27) Studied about bioaerosols release from activated sludge wastewater treatment plant by the method used to collect the bacteria were sedimentation method and impaction method and then performing an analysis of bacteria in groups as psychrophilic, mezophollic, positive manitol, manital-negative, Staphylococcus, Pseudomonas fluorescens. The study found that concentration of psychrophilic was range 14-5255 CFU/m^3, concentration of mezzophollic was range 1-1324 CFU/m^3, concentration of Staphylococcus was range 1-150 CFU/m^3. Pseudomonas fluorescens and Coli form bacteria found little and found bacteria in the return sludge pond and sludge drying areas more than anather areas. The aerator tank found concentration of bacteria closest to the common areas because the type of aerator (the turbine, the Kessner, the diffuse pipe) and size of aerator (large, medium, small).

Sanchez-Monederoa MA et all. (2008) (28) studied about impaction of the concentration of bioaerosols in the aerator system in activated sludge system wastewater treatment plant. They studied in 6 wastewater treatment plant in the South of Spain. They collected example only the bacteria, mesophilic types by using the tools in one-stage impactor. In wastewater treatment plant have been used 3 type aerators as the diffuse aerator, the horizontal rotation aerator and the surface aerator. The result that concentration of bacteria in the wastewater treatment plant use the horizontal rotation aerator and the wastewater treatment plant use the surface aerator have concentration of bacteria were rang 450 - 4580 CFU/m^3 and which were higher than concentration of bacteria in the wastewater treatment plant use the diffuse aerator was range 22 - 57 CFU/m^3. When the comparison concentration of bacteria in the wastewater treatment plant use the diffuse aerator between the background area wasn't difference with significantly , and it is possible that worker worked in the wastewater treatment plant use the horizontal rotation aerator and the wastewater treatment plant use the surface aerator will be affected health more than another.

Oppliger A et all. (2005) (29) studied about the influence of the season, and the evaluation of bioaerosols in a wastewater treatment plant in Swedish by study on 11 of the wastewater treatment plant. The collected sample of bacteria, fungi and endotoxin in the outdoor area and the indoor area in summer and winter, where collect the example on the worker exposure the risk. The result was concentration of fungi was the only higher with significantly in the summer over winter. Moreover found that concentration of bacteria in the indoor area near the pretreatment was higher than concentration of bacteria of the outdoor areas near the aeration pond in 2 seasons. Concentration of bioaerosols higher than the standard and especially workers who must work to clear the pond wastewater treatment, there will be a risk of exposure to bioaerosols at most.

CHAPTER III
MATERIALS AND METHODS

3.1 Study design

The study design was cross - sectional study to determine study concentration of bioaerosols in the wastewater treatment plant. The experiment was collecting the concentration of aerosols, bacteria and fungi in the workplace area of wastewater treatment plant where was in the area of office and the area around wastewater treatment plant. The experiment was collecting the concentration of aerosols, bacteria and fungi in the wastewater treatment plant was used surface aerator and diffused aerator. And the experiment was collecting the concentration of aerosols, bacteria and fungi in the upwind area and downwind area around wastewater treatment plant.

3.2 The sample

3.2.1 Study Group

The study group was 12 hospitals in affiliated Bangkok metropolitan.

3.2.2 Sample

3.2.2.1 Inclusion criteria

1) The size of the hospital from 600 beds.

2) Hospital's wastewater treatment system was an activated sludge system.

3) Activated Sludge system, the influence loading mass is less than 1,000 cubic meters per day.

3.2.2.2 Exclusion criteria

1) Incubate the agar plate didn't colony.

3.2.2.3 Sample size

The samples selected from hospitals that qualify under criteria (Purposive Sampling) which is a 4 hospital (A, B, C, D)

3.3 Instruments

3.2.1 Measure the concentration of aerosols is measure the particle size 1 – 10 micron by the optical scattering method with TSI Dusttrax DRX Aerosol Monitor Model 8533

3.2.2 Microflow α for bacteria and fungi sampling.

3.2.3 Air sampling media.

3.2.4.1 Plate count agar (PCA) for bacteria.

3.2.4.2 Potato Dextrose agar (PDA) for fungi.

3.2.4.3 Blood agar for select the type of bacteria.

3.2.4.4 Cereus selective agar for Bacillus spp.

3.2.5 Met one for wind direction

3.2.6 Anemometer for measure velocity.

3.2.7 WBGT Heat Stress monitor for measure temperature and humidity.

3.4 Bacteria, fungi and aerosols assessment

3.4.1 Sampling site

Location selected in this study is wastewater treatment plant at a hospital in Bangkok.

3.4.2 Sampling site layout

Select sampling points with sampling site location (Appendix; Figure A.1, Figure A.2, Figure A.3, Figure A.4)

3.4.3 Sampling schedule for concentration of aerosols bacteria and fungi

Aerosols samples, Bacteria samples and Fungi samples were collected in 2 period in the morning from 9.00 – 12.00 and the afternoon from 12.00 – 14.00. Aerosols samples were collected in 10 minute/point. Bacteria samples and Fungi samples were collected in 5 minute/point. The collected samples in 5 days (Monday, Tuesday, Wednesday, Thursday and Friday).The point of samples were 8 point.

- The area of office.
- The pretreatment tank.
- The side of aeration tank.
- The top of aeration tank.
- The side of sedimentation tank.
- The top of sedimentation tank.
- The downwind of wastewater treatment plant.
- The upwind of wastewater treatment plant.

3.4.4 Sampling schedule for select the type of bacteria and fungi

Bacteria samples and Fungi samples were collected 9.00 – 13.00. Bacteria samples and Fungi samples were collected in 5 minute/point. The point of samples were 5 point.

- The area of office.
- The side of aeration tank.
- The top of aeration tank.
- The side of sedimentation tank.
- The top of sedimentation tank.

3.4.5. Aerosol sampling method

- Before sampling, TSI Dusttrax DRX Aerosol Monitor Model 8533 was calibrated by zero filter.
- Place TSI Dusttrax DRX Aerosol Monitor Model 8533 in vertical position at height of 1.0-1.5 meter representing an average breathing zone and placed the sterile agar plate on plate holders and closed.

- TSI Dusttrax DRX Aerosol Monitor Model 8533 was collected 10 minutes .

- Measure temperature and humidity by using WBGT Heat Stress monitor and data were recorded.

- Measure wind direction by using Met one and data were recorded.

- Measure velocity by using Anemometer and data were recorded.

- After sampling completed, sampling time and sampling place were recorded.

3.4.6. Bacteria and fungi sampling method

- Before sampling, Microflow α was calibrated by calibration system designed by "Politecnico di Milano" at flow rate 30 L/minute volume 150 L.

- Use 70% alcohol to cleaned aluminum head and position to placed Microflow α before collecting air samples.

- Agar plate with agar sterile was placed on plate holders and closed

- Place Microflow α in vertical position at height of 1.0-1.5 meter representing an average breathing zone and placed the sterile agar plate on plate holders and closed.

- Microflow α was operated at flow rate 30 L/min for 5 minutes (30).

- Measure temperature and humidity by using WBGT Heat Stress monitor and data were recorded.

- Measure wind direction by using Met one and data were recorded.

- Measure velocity by using Anemometer and data were recorded.

- After sampling completed, sampling time and place were recorded.

- Agar plates after sampling were kept in plastic box and transferred to laboratory and incubation. For bacteria was incubated at 37 ºC for 48 hour and fungi at 25 ºC for 5 days. After incubation, the total count of microbial (cfu/m³) was calculated as follow.

$$\text{Colony forming unit/m3 (cfu/m}^3\text{)} = \frac{\text{Total colony on plate x 1000}}{\text{flow rate (L/min) x time of sampling (min)}}$$

3.4.7. The selection the type of bacteria sampling method

- Before sampling, Microflow α was calibrated by calibration system designed by "Politecnico di Milano" at flow rate 30 L/minute volume 150 L.
- Use 70% alcohol to cleaned aluminum head and position to placed Microflow α before collecting air samples.
- Blood agar plate with agar sterile was placed on plate holders and closed
- Place Microflow α in vertical position at height of 1.0-1.5 meter representing an average breathing zone and placed the sterile agar plate on plate holders and closed.
- Microflow α was operated at flow rate 30 L/min for 5 minutes.
- Measure temperature and humidity by using WBGT Heat Stress monitor and data were recorded.
- After sampling completed, sampling time and place were recorded.
- Agar plates after sampling were kept in plastic box and transferred to laboratory and incubation. For bacteria was incubated at 18 - 24 ºC for 48 hour. After incubation, the diagnosis of bacterial species by Biochemical reaction test. The total count of each bacterium (cfu/m³) was calculated as follow.

$$\text{Colony forming unit/m}^3\text{ (cfu/m}^3\text{)} = \frac{\text{Total colony on plate x 1000}}{\text{flow rate (L/min) x time of sampling (min)}}$$

3.4.8. The selection the type of fungi sampling method

- Before sampling, Microflow α was calibrated by calibration system designed by "Politecnico di Milano" at flow rate 30 L/minute volume 150 L.
- Use 70% alcohol to cleaned aluminum head and position to placed Microflow α before collecting air samples.
- Potato Dextrose agar plate with agar sterile was placed on plate holders and closed
- Place Microflow α in vertical position at height of 1.0-1.5 meter representing an average breathing zone and placed the sterile agar plate on plate holders and closed.
- Microflow α was operated at flow rate 30 L/min for 5 minutes.
- Measure temperature and humidity by using WBGT Heat Stress monitor and data were recorded.
- After sampling completed, sampling time and place were recorded.
- Agar plates after sampling were kept in plastic box and transferred to laboratory and incubation. For bacteria was incubated at 25 ºC for 5 days. After incubation, the diagnosis of fungi species by Biochemical reaction test. The total count of each fungus (cfu/m^3) was calculated as follow.

$$\text{Colony forming unit/m}^3\ (\text{cfu/m}^3) = \frac{\text{Total colony on plate x 1000}}{\text{flow rate (L/min) x time of sampling (min)}}$$

3.5 Statistical analysis

3.5.1 Descriptive statistic

Mean, standard deviation, maximum and minimum were used for analysis of general data such as bacteria counts, fungi count, temperature, humidity, velocity.

3.5.2 Inferential Statistics

- Mann-Whitney u test was used for comparison between the concentration of aerosols, bacteria and fungi in the area of office and area around the wastewater treatment plant.
- Mann-Whitney u test was used for compare the concentration of aerosols, bacteria and fungi in the wastewater treatment plant was used surface aerators and diffused aerators.
- Mann-Whitney u test was used for compare the concentration of aerosols, bacteria and fungi in the upwind area and in the downwind area.

CHAPTER IV
RESULTS

The results of this study were presented in 3 parts as the following:

4.1 General data

4.1.1. General data of the office buildings.

4.1.2. Temperature and humidity of the atmosphere and velocity of wind speed.

4.1.3. The wind direction in around wastewater treatment plants.

4.2 The comparison of variable

4.1.1 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in area around the wastewater treatment plants.

4.1.2 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in the background areas.

4.1.3 The comparison between concentration of aerosols, bacteria and fungi in area around the wastewater treatment plants and in the background areas.

4.1.4 The comparison between concentration of aerosols, bacteria and fungi in the wastewater treatment plants was used surface aerator and diffused aerator.

4.1.5 The comparison between concentration of aerosols, bacteria and fungi in the upwind areas and in the downwind areas at the wastewater treatment plant.

4.3 Type and concentration of bacteria and fungi in indoor offices and in area around the wastewater treatment plants.

4.1 General data

4.1.1 General data of the office buildings.

Size of office is 200 m^2 expect the hospital C is 400 m^2. Amount of controllers work in office is 4 people expect the hospital B is 8 people. Air condition system is spite type expect the hospital A is natural ventilation. Type of windows in the hospital A and D are casement, the hospital B is sliding and the hospital C is jalousie. Frequency of the door open were 30 time/hour expect the hospital A have open every time, as detailed in Table 4.1.

Table 4.1 General data of the office buildings.

Hospital	Size of office (m^2)	Amount of controller	Air condition system		Type of window	Frequency of the door open (time/hour)
			Natural	Spite type		
A	200	4	√		Casement	Open every time
B	200	8		√	Sliding	30
C	400	4		√	Jalousie	30
D	200	4		√	Casement	30

4.1.2 The temperature and humidity of the atmosphere and velocity of wind speed.

4.1.2.1 Temperature of indoor offices and in of the atmosphere around the wastewater treatment plant.

Temperature was measured at the time of sampling. The range temperature of in the area of offices was 21.00 – 36.00 $^{\circ}$C, the mean was 29.90 $^{\circ}$C and the median was 31.00 $^{\circ}$C.

The range temperature of the atmosphere around the wastewater treatment plant was 22.00 – 38.00 $^{\circ}$C, the mean was 31.87 $^{\circ}$C and the median was 32.00 $^{\circ}$C, as detailed in Table 4.2.

Table 4.2 Temperature of in the area of offices and of the atmosphere around the wastewater treatment plant.

Area	n	Min ($^{\circ}$C)	Max ($^{\circ}$C)	Mean(S.D) ($^{\circ}$C)	Median(Q) ($^{\circ}$C)
The area of offices	40	21.00	36.00	29.90 (4.07)	31.00 (Q_2)
The area around the wastewater treatment plant	360	22.00	38.00	31.87 (3.03)	32.00 (Q_2)

4.1.2.2 Humidity of in the area of offices and the area around wastewater treatment plant.

Humidity was measured at the time of sampling. The range humidity of in the area of offices was 34.00 – 60.00 %, the mean was 49.33% and the median was 50.00 %.

The range humidity of the atmosphere around the wastewater treatment plants was 22.00 – 80.00 %, the mean was 41.96% and the median was 42.00 %., as detailed in Table 4.3.

Table 4.3 Humidity of in the area of offices and the atmosphere around the wastewater treatment plants.

Area	n	Min (%)	Max (%)	Mean(S.D) (%)	Median(Q) (%)
The area of offices	40	34.00	60.00	49.33 (7.17)	50.00 (Q_2)
The area around the wastewater treatment plant	360	22.00	80.00	41.96 (8.41)	42.00 (Q_2)

4.1.2.3 Velocity of in the area of offices and in area around the wastewater treatment plant.

Velocity was measured at the time of sampling. The range velocity of in the area of offices was 0.11 – 3.52 m/s, the mean was 1.43 m/s and the median was 1.35 m/s.

The range velocity in area around the wastewater treatment plants was 0.14 – 6.00 m/s, the mean was 1.67 m/s and the median was 1.49 m/s., as detailed in Table 4.4.

Table 4.4 Velocity of in the area of offices and in area around the wastewater treatment plant.

Area	n	Min (m/s)	Max (m/s)	Mean(S.D) (m/s)	Median(Q) (m/s)
The area of offices	40	0.11	3.52	1.43 (1.01)	1.35 (Q_2)
The area around the wastewater treatment plant	360	0.14	6.00	1.67 (1.05)	1.49 (Q_2)

4.1.3 The wind direction in area around the wastewater treatment.

The wind direction measured by using Met one and data were as detailed in Table 4.5.

Table 4.5 The wind direction in area around the wastewater treatment plant.

Hospital	Days	9.00 – 12.00		12.00 – 14.00	
		Up Wind	Down Wind	Up Wind	Down Wind
A	1	SE	NW	SE	NW
	2	SE	NW	SE	NW
	3	NE	SW	NE	SW
	4	NW	SE	NW	SE
	5	NW	SE	NW	SE
B	1	W	E	W	E
	2	SW	NE	S	N
	3	NE	SW	NE	SW
	4	SE	NW	SE	NW
	5	SW	NE	SW	NE
C	1	S	N	N	S
	2	E	W	S	N
	3	S	N	S	N
	4	N	S	N	S
	5	NW	SE	N	S
D	1	SW	NE	SW	NE
	2	SW	NE	SW	NE
	3	SW	NE	SW	NE
	4	SW	NE	SW	NE
	5	SW	NE	SW	NE

4.2 The comparison of variable

4.2.1 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in area around the wastewater treatment plants.

4.2.1.1 The comparison between concentration of aerosols in the area of offices and in area around the wastewater treatment plants.

The range concentration of aerosols in the area of offices was 9.00 – 190.00 µg/m^3, the mean was 74.25 µg/m^3 and the median was 55.50 µg/m^3. The range concentration of aerosols in area around the wastewater treatment plant was 2.00 – 269.00 µg/m^3, the mean was 85.85 µg/m^3 and the median was 82.00 µg/m^3.

The test comparison the concentration of aerosols in the area of offices and in area around the wastewater treatment plants by Mann-Whitney u test. The results showed that concentration of aerosols in the area of offices weren't different concentration of aerosols in area around the wastewater treatment plants with 95% confidence, as detailed in Table 4.6.

Table 4.6 The comparison between concentration of aerosols in the area of offices and in area around the wastewater treatment plants.

Area	n	Min (µg/m^3)	Max (µg/m^3)	Mean(S.D) (µg/m^3)	Median(Q) (µg/m^3)	p-value
The area of offices	30	9.00	190.00	74.25 (47.71)	55.50 (Q_2)	0.276
In area around the wastewater treatment plants	320	2.00	269.00	85.85 (54.17)	82.00 (Q_2)	

4.2.1.2 The comparison between concentration of bacteria in indoor offices and in area around the wastewater treatment plants.

The range concentration of bacteria in indoor offices was 20.00 – 400.00 CFU/m^3, the mean was 92.85 CFU/m^3 and the median was 53.00 CFU/m^3. The range concentration of bacteria in area around the wastewater treatment plants was 20.00 – 16,513.00 CFU/m^3, the mean was 221.21 CFU/$m^3$and the median was 113.00 CFU/m^3.

The test comparison concentration of bacteria in indoor offices and concentration of bacteria in area around the wastewater treatment plants by Mann-Whitney u test. The results showed that concentration of bacteria in the area of offices were different concentration of bacteria in area around the wastewater treatments plant with 95% confidence (p-value < 0.05), as detailed in Table 4.7.

Table 4.7 The comparison between concentration of bacteria in the area of offices and in area around the wastewater treatment plants.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
The area of offices	30	20.00	400.00	92.85 (94.13)	53.00 (Q_2)	< 0.000*
In area around the wastewater treatment plant	316	20.00	16,513.00	221.21 (943.88)	113.00 (Q_2)	

* p-value < 0.05

4.2.1.3 The comparison between concentration of fungi in the area of offices and in area around the wastewater treatment plants.

The range concentration of fungi in the area of offices was 20.00 – 240.00 CFU/m^3, the mean was 45.80 CFU/m^3 and the median was 33.00 CFU/m^3. The range concentration of fungi in area around the wastewater treatment plants was 20.00 – 507.00 CFU/m^3, the mean was 105.87 CFU/$m^3$and the median was 80.00 CFU/m^3.

The test comparison concentration of fungi in the area of offices and concentration of fungi in area around the wastewater treatment plants by Mann-Whitney u test. The results showed that concentration of fungi in the area of offices were different concentration of fungi in area around the wastewater treatment plants with 95% confidence (p-value < 0.05), as detailed in Table 4.8.

Table 4.8 The comparison between concentration of fungi in the area of offices and in area around the wastewater treatment plants.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
The area of offices	27	20.00	240.00	45.80 (39.66)	33.00 (Q_2)	< 0.000*
In area around the wastewater treatment plant	310	20.00	507.00	105.87 (94.77)	80.00 (Q_2)	

* p-value < 0.05

4.2.2 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in the background areas.

4.2.2.1 The comparison between concentration of aerosols in the area of offices and in the background area.

The range concentration of aerosols in the area of offices was 9.00 – 190.00 µg/m^3, the mean was 74.25µg/m^3 and the median was 55.50µg/m^3. The range concentration of aerosols in the background areas was 7.00 – 191.00 µg/m^3, the mean was 85.50µg/m^3 and the median was 83.00 µg/m^3.

The test comparison the concentration of aerosols in the area of offices and in the background areas by Mann-Whitney u test. The results showed that concentration of aerosols in the area of offices weren't different concentration of aerosols in the background areas with 95% confidence, as detailed in Table 4.9.

Table 4.9 The comparison between concentration of aerosols in the area of offices and in the background area.

Area	n	Min (µg/m^3)	Max (µg/m^3)	Mean(S.D) (µg/m^3)	Median(Q) (µg/m^3)	p-value
The area of offices	30	9.00	190.00	74.25 (47.71)	55.50 (Q_2)	0.292
The background areas	40	7.00	191.00	85.50 (48.41)	83.00 (Q_2)	

4.2.2.2 The comparison between concentration of bacteria in the area of offices and in the background area.

The range concentration of bacteria in the area of offices was 20.00 – 400.00 CFU/m^3, the mean was 92.85 CFU/m^3 and the median was 53.00 CFU/m^3. The range concentration of bacteria in the background areas was 20.00 – 1,600.00 CFU/m^3, the mean was 193.79 CFU/$m^3$and the median was 100.00 CFU/m^3.

The test comparison concentration of bacteria in the area of offices and concentration of bacteria in the background areas by Mann-Whitney u test. The results showed that concentration of bacteria in the area of offices were different concentration of bacteria in the background areas with 95% confidence (p-value < 0.05), as detailed in Table 4.10.

Table 4.10 The comparison between concentration of bacteria in the area of offices and in the background area.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
The area of offices	30	20.00	400.00	92.85 (94.13)	53.00 (Q_2)	0.024*
The background area	39	20.00	1,600.00	193.79 (275.65)	100.00 (Q_2)	

* p-value < 0.05

4.2.1.3 The comparison between concentration of fungi in the area of offices and in the background area.

The range concentration of fungi in the area of offices was 20.00 – 240.00 CFU/m^3, the mean was 45.80 CFU/m^3 and the median was 33.00 CFU/m^3. The range concentration of fungi in the background areas was 20.00 – 373.00 CFU/m^3, the mean was 120.68 CFU/$m^3$and the median was 93.00 CFU/m^3.

The test comparison concentration of fungi in the area of offices and concentration of fungi in the background areas by Mann-Whitney u test. The results showed that concentration of fungi in the area of offices were different concentration of fungi in the background areas with 95% confidence (p-value < 0.05), as detailed in Table 4.11.

Table 4.11 The comparison between concentration of fungi in the area of offices and in the background area.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
The area of offices	27	20.00	240.00	45.80 (39.66)	33.00 (Q_2)	< 0.000*
The background area	38	20.00	373.00	120.68 (96.25)	93.00 (Q_2)	

* p-value < 0.05

4.2.3 The comparison between concentration of aerosols, bacteria and fungi in area around the wastewater treatment plants and in background areas.

4.2.3.1 The comparison between concentration of aerosols in area around the wastewater treatment plants and in the background areas.

The range concentration of aerosols in area around the wastewater treatment plants was 2.00 – 269.00 µg/m^3, the mean was 85.85 µg/m^3 and the median was 82.00 µg/m^3. The range concentration of aerosols in the background areas was 7.00 – 191.00 µg/m^3, the mean was 85.50 µg/m^3 and the median was 83.00 µg/m^3.

The test comparison the concentration of aerosols in area around the wastewater treatment plants and in the background areas by Mann-Whitney u test. The results showed that concentration of aerosols in area around the wastewater treatment plants weren’t different concentration of aerosols in the background areas with 95% confidence, as detailed in Table 4.12.

Table 4.12 The comparison between concentration of aerosols in area around the wastewater treatment plants and in the background areas.

Area	n	Min (µg/m^3)	Max (µg/m^3)	Mean(S.D) (µg/m^3)	Median(Q) (µg/m^3)	p-value
In area around the wastewater treatment plant	320	2.00	269.00	85.85 (54.17)	82.00 (Q_2)	0.851
The background area	40	7.00	191.00	85.50 (48.41)	83.00 (Q_2)	

4.2.3.2 The comparison between concentration of bacteria in area around the wastewater treatment plants and in the background areas.

The range concentration of bacteria in area around the wastewater treatment plan**ts** was 20.00 – 16,513.00 CFU/m^3, the mean was 221.21 CFU/m^3 and the median was 113.00 CFU/m^3. The range concentration of bacteria in the background areas was 20.00 – 1,600.00 CFU/m^3, the mean was 193.79 CFU/m^{3}and the median was 100.00 CFU/m^3.

The test comparison concentration of bacteria in area around the wastewater treatment plant and concentration of bacteria in the background areas by Mann-Whitney u test. The results showed that concentration of bacteria in area around the wastewater treatment plan**ts** weren’t different concentration of bacteria in the background areas with 95% confidence, as detailed in Table 4.13.

Table 4.13 The comparison between concentration of bacteria in area around the wastewater treatment plants and in the background areas.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
In area around the wastewater treatment plant	316	20.00	16,513.00	221.21 (943.88)	113.00 (Q_2)	0.781
The background area	39	20.00	1,600.00	193.79 (275.65)	100.00 (Q_2)	

4.2.3.3 The comparison between concentration of fungi in area around the wastewater treatment plants and in the background areas.

The range concentration of fungi in area around the wastewater treatment plants was 20.00 – 507.00 CFU/m^3, the mean was 105.87 CFU/m^3 and the median was 80.00 CFU/m^3. The range concentration of fungi in the background areas was 20.00 – 373.00 CFU/m^3, the mean was 120.68 CFU/m^3 and the median was 93.00 CFU/m^3.

The test comparison concentration of fungi in area around the wastewater treatment plant**s** and concentration of fungi in the background areas by Mann-Whitney u test. The results showed that concentration of fungi in area around the wastewater treatment plants weren't different concentration of fungi in the background areas with 95% confidence, as detailed in Table 4.14.

Table 4.14 The comparison between concentration of fungi in area around the wastewater treatment plants and in the background areas.

Area	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
In area around the wastewater treatment plants	310	20.00	507.00	105.87 (94.77)	80.00 (Q_2)	0.335
The background areas	38	20.00	373.00	120.68 (96.25)	93.00 (Q_2)	

* p-value < 0.05

4.2.4 The comparison between concentration of aerosols, bacteria and fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

4.2.4.1 The comparison between concentration of aerosols in the wastewater treatment plant was used surface aerator and diffused aerator.

The range concentration of aerosols in the wastewater treatment plant used surface aerators was 2.00 – 268.00 µg/m^3, the mean was 71.58 µg/m^3 and the median was 72.50 µg/m^3. The range concentration of aerosols in the wastewater treatment plant used diffused aerators was 9.00 – 269.00 µg/m^3, the mean was 97.54 µg/m^3 and the median was 90.00 µg/m^3.

The test comparison the concentration of aerosols in the wastewater treatment plant was used surface aerator and in diffused aerator by Mann-Whitney u test. The results showed that concentration of aerosols in the wastewater treatment plant used surface aerator were different concentration of aerosols in the wastewater treatment plant used diffused aerator with 95% confidence (p-value < 0.05), as detailed in Table 4.15.

Table 4.15 The comparison between concentration of aerosols in the wastewater treatment plant was used surface aerator and diffused aerators.

Aerator Systems	n	Min (µg/m^3)	Max (µg/m^3)	Mean(S.D) (µg/m^3)	Median(Q) (µg/m^3)	p-value
Surface aerator	180	2.00	268.00	71.58,(42.58)	72.50, (Q2)	< 0.000*
Diffused aerator	180	9.00	269.00	97.54,(60.01)	90.00, (Q2)	

* p-value < 0.05

4.2.4.2 The comparison between concentration of bacteria in the wastewater treatment plant was used surface aerator and diffused aerator.

The range concentration of bacteria in the wastewater treatment plant used surface aerator was 20.00 – 2,560.00 CFU/m^3, the mean was 175.13 CFU/$m^3$and the median was 93.00 CFU/m^3. The range concentration of bacteria in the wastewater treatment plant used diffused aerator was 20.00 – 16,513.00 CFU/m^3, the mean was 247.44 CFU/$m^3$and the median was 113.00 CFU/m^3.

The test comparison the concentration of bacteria in the wastewater treatment plant used surface aerator and in the wastewater treatment plant used diffused aerator by Mann-Whitney u test. The results showed that concentration of bacteria in the wastewater treatment plant used surface aerator weren't different concentration of bacteria in the wastewater treatment plant used diffused aerator with 95% confidence, as detailed in Table 4.16.

Table 4.16 The comparison between concentration of bacteria in the wastewater treatment plant was used surface aerator and diffused aerators.

Aerator Systems	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
Surface aerator	180	20.00	2,560.00	175.13, (250.71)	93.00, (Q2)	0.110
Diffused aerator	180	20.00	16,513.00	247.44, (1,250.15)	113.00,(Q2)	

4.2.4.3 The comparison between concentration of fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

The range concentration of fungi in the wastewater treatment plant used surface aerator was 20.00 – 480.00 CFU/m^3, the mean was 93.50 CFU/$m^3$and the median was 60.00 CFU/m^3. The range concentration of fungi in the wastewater treatment plant used diffused aerator was 20.00 – 507.00 CFU/m^3, the mean was 106.94 CFU/$m^3$and the median was 80.00 CFU/m^3.

The test comparison the concentration of fungi in the wastewater treatment plant used surface aerator and in the wastewater treatment plant used diffused aerator by Mann-Whitney u test. The results showed that concentration of fungi in the wastewater treatment plant used surface aerator were different concentration of fungi in the wastewater treatment plant used diffused aerator with 95% confidence (p-value < 0.05), as detailed in Table 4.17.

Table 4.17 The comparison between concentration of fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

Aerator Systems	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
Surface aerator	180	20.00	480.00	93.50,(90.81)	60.00, (Q2)	0.015*
Diffused aerator	180	20.00	507.00	106.94,(94.42)	80.00, (Q2)	

* p-value < 0.05

4.2.5 The comparison between concentration of aerosols, bacteria and fungi in the upwind area and in downwind area.

4.2.5.1 The comparison between concentration of aerosols in the upwind area and in downwind area.

The range concentration of aerosols in the upwind area was 12.00 – 237.00 µg/m^3, the mean was 92.70 µg/m^3 and the median was 89.00 µg/m^3. The range concentration of aerosols in the downwind area was 2.00 – 269.00 µg/m^3, the mean was 88.73 µg/m^3 and the median was 83.50 µg/m^3.

The test comparison the concentration of aerosols in the upwind area and in the downwind area by Mann-Whitney u test. The results showed that concentration of aerosols in the upwind area weren't different concentration of aerosols in the downwind area with 95% confidence, as detailed in Table 4.18.

Table 4.18 The comparison between concentration of aerosols in the upwind area and in the downwind area.

Wind direction	n	Min (µg/m^3)	Max (µg/m^3)	Mean(S.D) (µg/m^3)	Median(Q) (µg/m^3)	p-value
upwind	61	12.00	237.00	92.70,(54.23)	89.00, (Q2)	0.523
downwind	236	2.00	269.00	88.73,(56.60)	83.50, (Q2)	

4.2.5.2 The comparison between concentration of bacteria in the upwind area and in downwind area.

The range concentration of bacteria in the upwind area was 20.00 – 613.00 CFU/m^3, the mean was 139.05 CFU /m^3 and the median was 100.00 CFU /m^3. The range concentration of bacteria in the downwind area was 20.00 – 16,513.00 CFU /m^3, the mean was 252.96 CFU/m^3 and the median was 120.00 CFU /m^3.

The test comparison the concentration of bacteria in the upwind area and in the downwind area by Mann-Whitney u test. The results showed that concentration of bacteria in the upwind area weren't different concentration of bacteria in the downwind area with 95% confidence, as detailed in Table 4.19.

Table 4.19 The comparison between concentration of bacteria in the upwind area and in downwind area.

Wind direction	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
upwind	61	20.00	613.00	139.05, (116.98)	100.00, (Q2)	0.557
downwind	236	20.00	16,513.00	252.96, (1,088.93)	120.00, (Q2)	

4.2.5.3 The comparison between concentration of fungi in the upwind area and in downwind area.

The range concentration of fungi in upwind area was 20.00 – 420.00 CFU/m^3, the mean was 97.95 CFU /m^3 and the median was 67.00 CFU /m^3. The range concentration of fungi in downwind area was 20.00 – 507.00 CFU /m^3, the mean was 113.12 CFU/m^3 and the median was 80.00 CFU /m^3.

The test comparison the concentration of fungi in the upwind area and in downwind area by Mann-Whitney u test. The results showed that concentration of fungi in the upwind area weren't different concentration of fungi in downwind area with 95% confidence, as detailed in Table 4.20.

Table 4.20 The comparison between concentration of fungi in the upwind area and in downwind area.

Wind direction	n	Min (CFU/m^3)	Max (CFU/m^3)	Mean(S.D) (CFU/m^3)	Median(Q) (CFU/m^3)	p-value
upwind	61	20.00	420.00	97.95, (87.50)	67.00, (Q2)	0.245
downwind	236	20.00	507.00	113.12, (101.63)	80.00, (Q2)	

4.3 Type and concentration of bacteria and fungi in the area of offices and in area around the wastewater treatment plants.

4.3.1 Type and concentration of bacteria in the area of offices and in area around the wastewater treatment plants.

Type and concentration of bacteria in the area of offices show that the mean of gram positive was 463.33 CFU/m^3 (81%), the mean of gram negative was 46.67 CFU/m^3 (8 %) and the mean of Bacillus spp. was 63.33 CFU/m^3 (11%).

Type and concentration of bacteria in area around the wastewater treatment plants show that the mean of gram positive was 529.16 CFU/m^3 (68%) ,the mean of gram negative was 58.52 CFU/m^3 (7%) and the mean of Bacillus spp. was 194.22 CFU/m^3 (25%), as detailed in Table 4.21., figure 4.1 and figure 4.2

Table 4.21 Type and concentration of bacteria in the area of offices and in area around the wastewater treatment plant.

Area	Type and concentration of bacteria (CFU/m^3)		
	Gram positive. Mean(S.D)	Gram negative. Mean(S.D)	Bacillus spp. Mean(S.D)
The area of offices	463.33 (424.21)	46.67 *	63.33 (42.43)
Around wastewater treatment plant.	529.16 (636.90)	58.52 (55.56)	194.22 (242.85)

* Sample found gram negative only one plate.

4.3.2 Type and concentration of fungi in the area of offices and in area around the wastewater treatment plant.

Type and concentration of fungi in the area of offices show that the mean of Aspergillus niger was 21.67 CFU/m^3 (29%) ,the mean of Fusarium spp. was 33.34 CFU/m^3 44%) and the mean of Penicillum spp.was 20 CFU/m^3 (27%).

Type and concentration of fungi in area around the wastewater treatment plant show that the mean of Aspergillus niger was 51.11 CFU/m^3 (39%) ,the mean of Aspergillus flavus was 26.67 CFU/m^3 (20%) ,the mean of Fusarium spp. was 32.38 CFU/m^3 (25%) and the mean of Penicillum spp was 21.67 CFU/m^3 (16%), as detailed in Table 4.22., figure 4.3 and figure 4.4

Table 4.22 Type and concentration of fungi in the area of offices and in area around the wastewater treatment plant.

Area	Type and concentration of fungi (CFU/m^3)			
	Aspergillus niger Mean(S.D)	Aspergillus flavus Mean(S.D)	Fusarium spp. Mean(S.D)	Penicillum spp. Mean(S.D)
The area of offices	21.67 (3.34)	-	33.34 (18.86)	20 **
Around wastewater treatment plant	51.11 (21.90)	26.67 *	32.38 (18.46)	21.67 (3.34)

* Sample found gram negative only one plate.

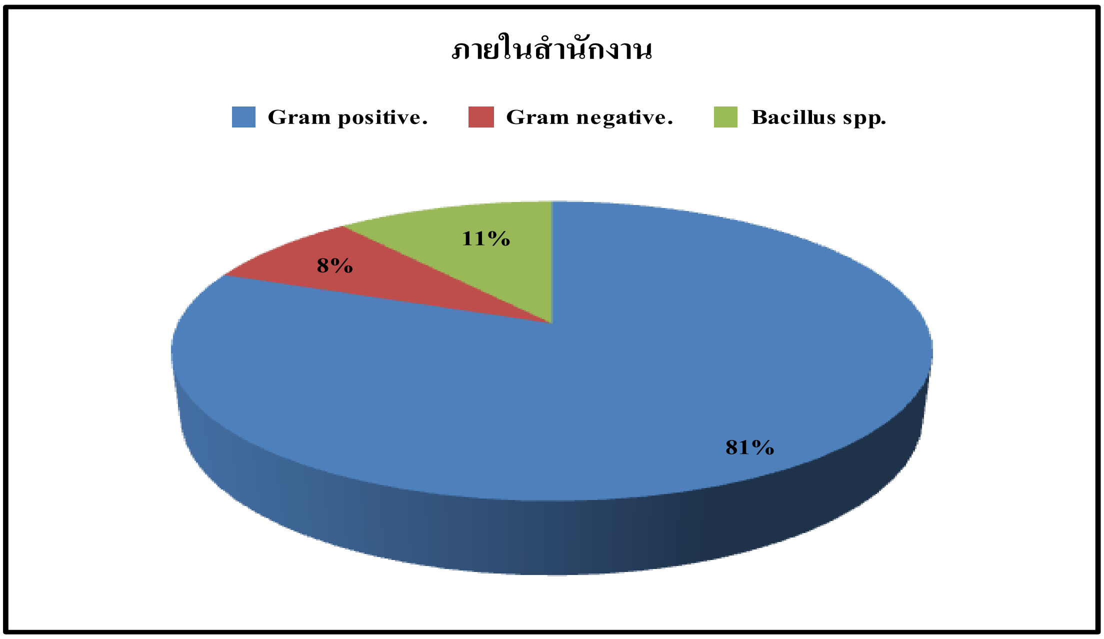

Figure 4.1 Type and concentration of bacteria in the area of offices

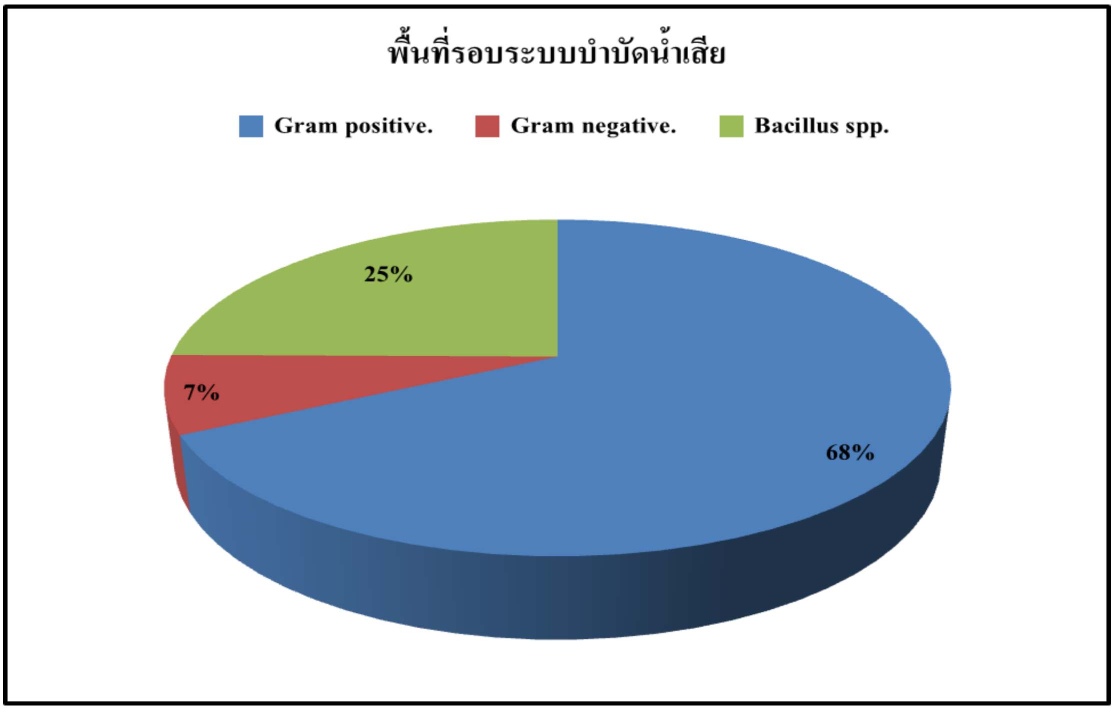

Figure 4.2 Type and concentration of bacteria in area around the wastewater treatment plant

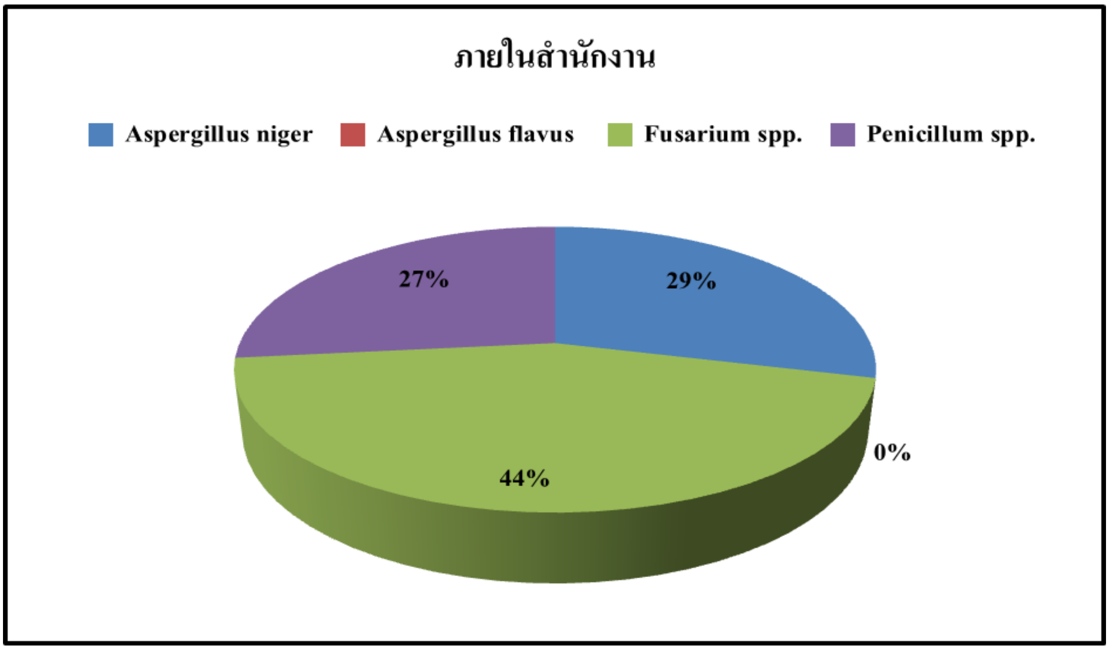

Figure 4.3 Type and concentration of fungi in the area of offices

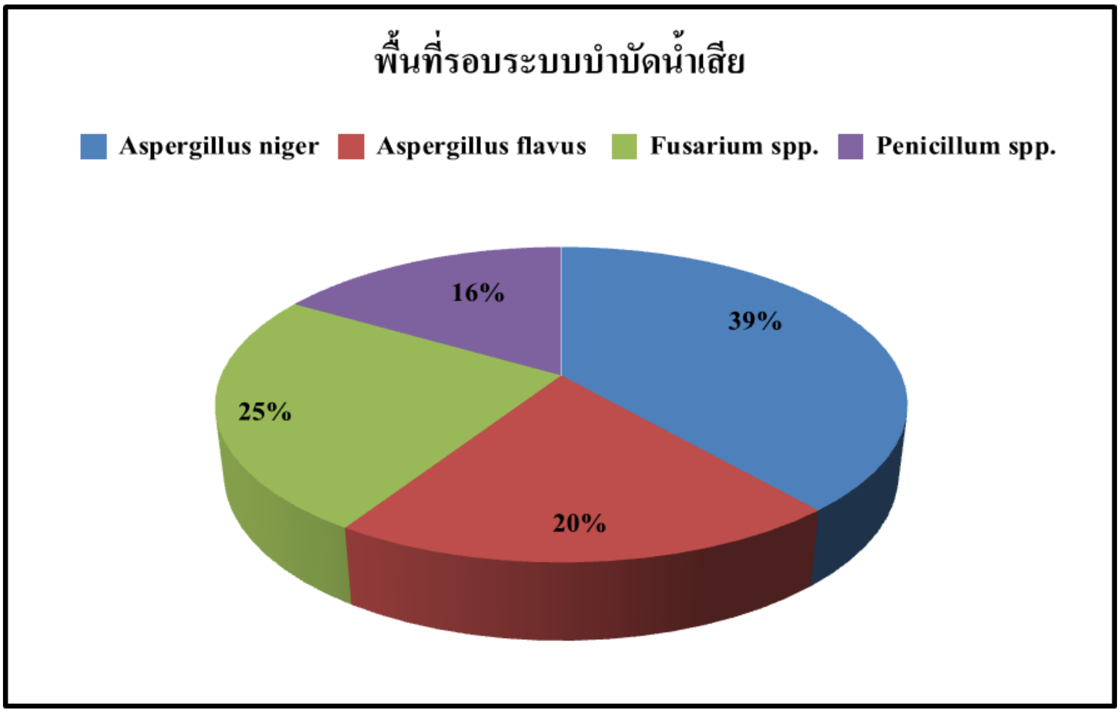

Figure 4.4 Type and concentration of fungi in area around the wastewater treatment plant

CHAPTER V
DISCUSSION

5.1 Discussion on the study method

5.1.1 Collection of aerosols

Aerosols samples were collected using TSI Dusttrax DRX Aerosol Monitor Model 8533 by collect 2 period in the morning and the afternoon. There was 10 point collected samples and time of samples were 10 minute/point sometime battery of instrument was less than 10% so reduced flow rate and to keep the sample aerosol is not fully. How to solve the problem by the instrument resumed electricity directly. There was turn off the door almost all the time during collection in the area of offices.

5.1.2 Collection of microbial.

Microbial air samples (bacteria and fungi) were collected using Microflow 90 at flow rate 30 L/minute sometime flow rate were error flow because the windblown so much strength. How to solve the problem by avoid collected samples at wind and instrument calibrated before collection.

5.1.3 Area of wastewater treatment plant.

The area of the wastewater treatment plant in each hospital weren't the same and the some hospitals, there were small areas and surrounding area had the tall building, the tall wall, many tree and many the big papyrus so the area of collection weren't appropriate. How to solve the problem by collection in nearby area.

5.2 Discussion on the study result

5.2.1 Temperature and humidity of the atmosphere and velocity of wind speed.

The present study was conducted almost 3 month during October to December (rain season and early winter season) by collection in the area of offices and area around wastewater treatment plants.

5.2.1.1 Temperature

Temperature of the area of offices was the mean and the median were lower than area around wastewater treatment plants. In previous studies stated that, The concentrations of microbial depend on environmental factors, such as temperature, relative humidity, wind velocity and season (31).

5.2.1.2 Humidity

Humidity of the area of offices was the mean and the median were higher than area around wastewater treatment plants. In previous studies stated that, The concentrations of microbial depend on environmental factors, such as temperature, relative humidity, wind velocity and season (31).

5.2.1.3 Velocity of wind speed

Velocity of the area of offices was the mean and the median were lower than area around wastewater treatment plants. In previous studies stated that, The concentrations of microbial depend on environmental factors, such as temperature, relative humidity, wind velocity and season (31).

5.2.2 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in area around the wastewater treatment plant.

5.2.2.1 The comparison between concentration of aerosols in the area of offices and in area around the wastewater treatment plant.

The present study was the mean and the median of concentration of aerosols in the area of offices were lower than in area around wastewater treatment plants. Comparison concentration of aerosols in the area of offices weren't difference in area around wastewater treatment plants with 95%

confidence .In general fact of office building show that the office building have many window and they aren't seal. The outdoor air can flow to indoor air office building other than the frequency of opening – closing doors, it would have outdoor air can flow into indoor air so it affect to aerosol of indoor.

5.2.2.2 The comparison between concentration of bacteria in the area of offices and in area around the wastewater treatment plant.

The present study was the mean and the median of concentration of bacteria in the area of offices were lower than around wastewater treatment plants. Katsivela E and Karrar,(5) reported similar result that concentration of bacteria in indoor air lower than the wastewater treatment outdoor air and comparison concentration of bacteria in the area of offices were difference in area around wastewater treatment plants with 95% confidence .

5.2.2.3 The comparison between concentration of fungi in the area of offices and in area around the wastewater treatment plant.

The present study was the mean and the median of concentration of fungi in the area of offices were lower than in area around wastewater treatment plants. Katsivela E and Karrar,(5) reported similar result that concentration of fungi in indoor air lower than the wastewater treatment outdoor air and comparison concentration of fungi in the area of offices were difference around wastewater treatment plants with 95% confidence .

5.2.3 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in the background areas.

5.2.3.1 The comparison between concentration of aerosols in the area of offices and in the background areas.

The present study was the mean and the median of concentration of aerosols in the area of offices were lower than in the background areas. Comparison concentration of aerosols in the area of offices weren't difference in the background areas with 95% confidence.

5.2.3.2 The comparison between concentration of bacteria in the area of offices and in the background areas.

The present study was the mean and the median of concentration of bacteria in the area of offices were lower than in the background areas. Katsivela E and Karrar,(5) reported similar result that concentration of bacteria in indoor air lower than the baseline outdoor air and comparison concentration of bacteria in the area of offices were difference in the background areas with 95% confidence .

5.2.3.3 The comparison between concentration of fungi in the area of offices and in the background areas.

The present study was the mean and the median of concentration of fungi in the area of offices were lower than in the background areas. Katsivela E and Karrar,(5) reported similar result that concentration of fungi in indoor air lower than the baseline outdoor air and comparison concentration of fungi in the area of offices were difference in the background areas with 95% confidence .

5.2.4 The comparison between concentration of aerosols, bacteria and fungi in area around wastewater treatment plants and in the background areas.

5.2.4.1 The comparison between concentration of aerosols in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of aerosols in in the area around the wastewater treatment plants were higher than in the background areas. Comparison concentration of fungi in the area around the wastewater treatment plants weren't difference in the background areas with 95% confidence.

5.2.4.2 The comparison between concentration of bacteria in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of bacteria in in area around the wastewater treatment plants were lower than in the background areas. Comparison concentration of bacteria in in the area around the wastewater treatment plants weren't difference in background areas with 95% confidence.

5.2.4.2 The comparison between concentration of fungi in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of fungi in area around the wastewater treatment plants were lower than in the background areas. Comparison concentration of fungi in area around the wastewater treatment plants weren't difference in background areas with 95% confidence.

5.2.5 The comparison between concentration of aerosols, bacteria and fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

5.2.5.1 The comparison between concentration of aerosols in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of aerosols in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. Comparison concentration of aerosols in the wastewater treatment plant used surface aerator were difference in the wastewater treatment plant used diffused aerator with 95% confidence.

5.2.5.2 The comparison between concentration of bacteria in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of bacteria in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. This study were in contrast with those reported by Sanchez-Monederoa MA (28) that concentration of bacteria in the surface aerator system were higher than in the diffused aerator system and comparison concentration of bacteria in the wastewater treatment plant used surface aerator system weren't difference in the wastewater treatment plant used diffused aerator system with 95% confidence. The physical characteristics of the aerator were affect to concentration of bacteria, Bauer H et all, (6) reported concentration of bioaerosols in the waste water treatment plant use of the surface aerator were higher than other type of aerator but it all depends on the cross sectional area of the pond fills ,characteristic of wastewater and number of aerators.

5.2.5.3 The comparison between concentration of fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of fungi in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. This study were in contrast with those reported by Sanchez-Monederoa MA (28) that concentration of fungi in the surface aerator system were higher than in the diffused aerator system and comparison concentration of fungi in the wastewater treatment plant used surface aerator were difference in the wastewater treatment plant used diffused aerator with 95% confidence.

5.2.6 The comparison between concentration of aerosols, bacteria and fungi in the upwind area and in the downwind area.

5.2.6.1 The comparison between concentration of aerosols in the upwind area and in the downwind area**.**

The present study was the mean and the median of concentration of aerosols in the upwind area were higher than in the downwind area. Comparison concentration of aerosols in the upwind area weren't difference in the downwind area. This seems to be caused by wind blowing almost constantly and there was the tall building surrounding area, cause the wind blows the variance at any time.

5.2.6.2 The comparison between concentration of bacteria in the upwind area and in the downwind area**.**

The present study was the mean and the median of concentration of bacteria in the upwind area were lower than in the downwind area. Stellacci et all, Fannin KF et all, Brandi et all (8,9,25) reported similar result that concentration of bioaerosols in the upwind were lower than in the downwind but comparison concentration of bacteria in the upwind area weren't difference in the downwind area. This seems to be caused by wind blowing almost constantly and there was the tall building surrounding area, cause the wind blows the variance at any time.

5.2.6.3 The comparison between concentration of fungi in the upwind area and in the downwind area**.**

The present study was the mean and the median of concentration of fungi in the upwind area were lower than in the downwind area. Stellacci et all, Fannin KF et all, Brandi et all (8,9,25) reported similar result that concentration of bioaerosols in the upwind were lower than in the downwind but comparison concentration of fungi in the upwind area weren't difference in the downwind area. This seems to be caused by wind blowing almost constantly and there was the tall building surrounding area, cause the wind blows the variance at any time.

5.3 Type and concentration of bacteria and fungi in the workplace area of the wastewater treatment plant (Activated Sludge) controller working.

5.3.1 Type and concentration of bacteria in indoor offices and in area around the wastewater treatment plants.

The present study was type of bacteria find in indoor offices that the most species bacterium was gram positive and in area around the wastewater treatment plants found the most species bacterium was gram positive too. This study was in contrast with those reported by Orsini et all (7) that the most species bacterium was gram negative.

5.3.2 Type and concentration of fungi in indoor offices and in area around the wastewater treatment plants.

The present study was type of fungi find in indoor offices that the most species fungus was Aspergillus niger and in area around the wastewater treatment plants found the most species fungus was Aspergillus niger too.

CHAPTER VI
CONCLUSION

6.1 Conclusion

This experiment was comparison factor affect to concentration of bioaerosols in wastewater treatment plant by study 3 factor, there was area of the controller working, type of aerator which wastewater treatment plant used in aerator tank and the wind direction in upwind and downwind surrounding wastewater treatment plant.

6.1.1 The comparison between concentration of aerosols, bacteria and fungi in the area of offices and in area around the wastewater treatment plants.

6.1.1.1 The comparison between concentration of aerosols in the area of offices and in the area around the wastewater treatment plants.

The present study was the mean and the median of concentration of aerosols in the area of offices were lower than around wastewater treatment plants. Comparison concentration of aerosols in the area of offices weren't difference around wastewater treatment plants with 95% confidence.

6.1.1.2 The comparison between concentration of bacteria in the area of offices and in the area around the wastewater treatment plants.

The present study was the mean and the median of concentration of bacteria in the area of offices were lower than around wastewater treatment plants. Comparison concentration of bacteria in the area of offices were difference around wastewater treatment plants with 95% confidence.

6.1.1.3 The comparison between concentration of fungi in the area of offices and in the area around the wastewater treatment plants.

The present study was the mean and the median of concentration of fungi in the area of offices were lower than around wastewater treatment plants. Comparison concentration of fungi in the area of offices were difference around wastewater treatment plants with 95% confidence.

6.1.2 The comparison between concentration of aerosols, bacteria and fungi in indoor offices and in the background areas.

6.1.2.1 The comparison between concentration of aerosols in the area of offices and in the background areas.

The present study was the mean and the median of concentration of aerosols in the area of offices were lower than in the background areas. Comparison concentration of aerosols in the area of offices weren't difference in the background areas with 95% confidence.

6.1.2.2 The comparison between concentration of bacteria in the area of offices and in the background areas.

The present study was the mean and the median of concentration of bacteria in the area of offices were lower than in the background areas. Comparison concentration of bacteria in the area of offices were difference in the background areas with 95% confidence.

6.1.2.3 The comparison between concentration of fungi in the area of offices and in the background areas.

The present study was the mean and the median of concentration of fungi in the area of offices were lower than in the background areas. Comparison concentration of fungi in the area of offices were difference in the background areas with 95% confidence.

6.1.3 The comparison between concentration of aerosols, bacteria and fungi in area around the wastewater treatment plants and in the background areas.

6.1.3.1 The comparison between concentration of aerosols in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of aerosols in area around the wastewater treatment plants were higher than in the background areas. Comparison concentration of fungi in area around the wastewater treatment plants weren’t difference in the background areas with 95% confidence.

6.1.3.2 The comparison between concentration of bacteria in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of bacteria in area around the wastewater treatment plants were lower than in the background areas. Comparison concentration of bacteria in area around the wastewater treatment plants weren’t difference in the background areas with 95% confidence.

6.1.3.3 The comparison between concentration of fungi in area around the wastewater treatment plants and in the background areas.

The present study was the mean and the median of concentration of fungi in area around the wastewater treatment plants were lower than in the background areas. Comparison concentration of fungi in area around the wastewater treatment plants weren’t difference in the background areas with 95% confidence.

6.1.4 The comparison between concentration of aerosols, bacteria and fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

6.1.4.1 The comparison between concentration of aerosols in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of aerosols in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. Comparison concentration of aerosols in the wastewater treatment plant used surface aerator were difference in the wastewater treatment plant used diffused aerator with 95% confidence.

6.1.4.2 The comparison between concentration of bacteria in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of bacteria in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. Comparison concentration of bacteria in the wastewater treatment plant used surface aerator weren't difference in the wastewater treatment plant used diffused aerator with 95% confidence.

6.1.4.3 The comparison between concentration of fungi in the wastewater treatment plant was used surface aerator and diffused aerator.

The present study was the mean and the median of concentration of fungi in the wastewater treatment plant used surface aerator were lower than in the wastewater treatment plant used diffused aerator. Comparison concentration of fungi in the wastewater treatment plant used surface aerator were difference in the wastewater treatment plant used diffused aerator with 95% confidence.

6.1.5 The comparison between concentration of aerosols, bacteria and fungi in the upwind area and in the downwind area.

6.1.5.1 The comparison between concentration of aerosols in the upwind area and in the downwind area.

The present study was the mean and the median of concentration of aerosols in the upwind area were higher than in the downwind area. Comparison concentration of aerosols in the upwind area weren't difference in the downwind area with 95% confidence.

6.1.5.2 The comparison between concentration of bacteria in the upwind area and in the downwind area.

The present study was the mean and the median of concentration of bacteria in the upwind area were lower than in the downwind area. Comparison concentration of bacteria in the upwind area weren't difference in the downwind area with 95% confidence.

6.1.5.3 The comparison between concentration of fungi in the upwind area and in the downwind area.

The present study was the mean and the median of concentration of fungi in the upwind area were lower than in the downwind area. Comparison concentration of fungi in the upwind area weren't difference in the downwind area with 95% confidence.

6.2 Recommendations

6.2.1 Recommendation from the finding of this study

6.2.1.1 The present study was area of the controller working affect to concentration of bacteria and fungi and type of aerator which wastewater treatment plant used in aerator tank affect to concentration of aerosols and fungi but wind direction wasn't affect to bioaerosols.

6.2.1.2 There should be an explanation of risk exposure to bioaerosols in the wastewater treatment plant area, with workers of hospital who work near the wastewater treatment plant, not only controller because in the area located near the wastewater treatment plant where it is exposure to the same risks.

6.2.1.3 There should be reduce the risk of exposure to bioaerosols and ventilation system should be efficient in filtering dust or aerosols for reduce the health risk for worker in office. Those who work in the wastewater treatment plant area should be used personal protective equipment at all time and they can protective from bioaerosols as N95 mask etc.

6.2.1.4 There should be alert for patients, children, elderly, not to go in the wastewater treatment plant area, or if who will go in area they must used personal protective equipment at all time for reduce the risk of exposure bioaerosols.

6.2.2 Recommendation for further studies

6.2.2.1 Quantity study of bioaerosols from on the cross sectional area of the wastewater treatment plant.

6.2.1.2 Quantity of bioaerosols from wastewater treatment plant with type of aerator.

6.2.1.3 Quantity of bioaerosols that caused a number of aerator in wastewater treatment plant.

6.2.1.4 Study and evaluation of biological risk that worker wastewater treatment plant exposure.

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APPENDIX

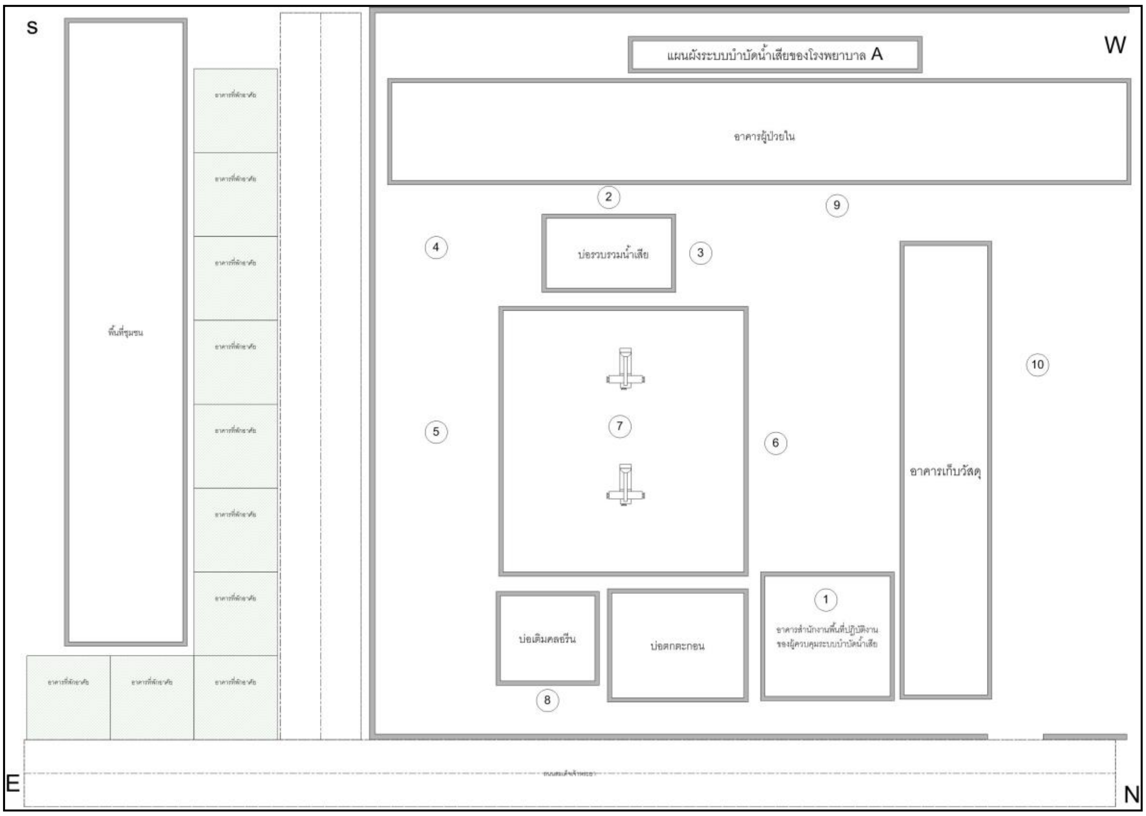

Fig. A.1 Sampling size layout hospital A.

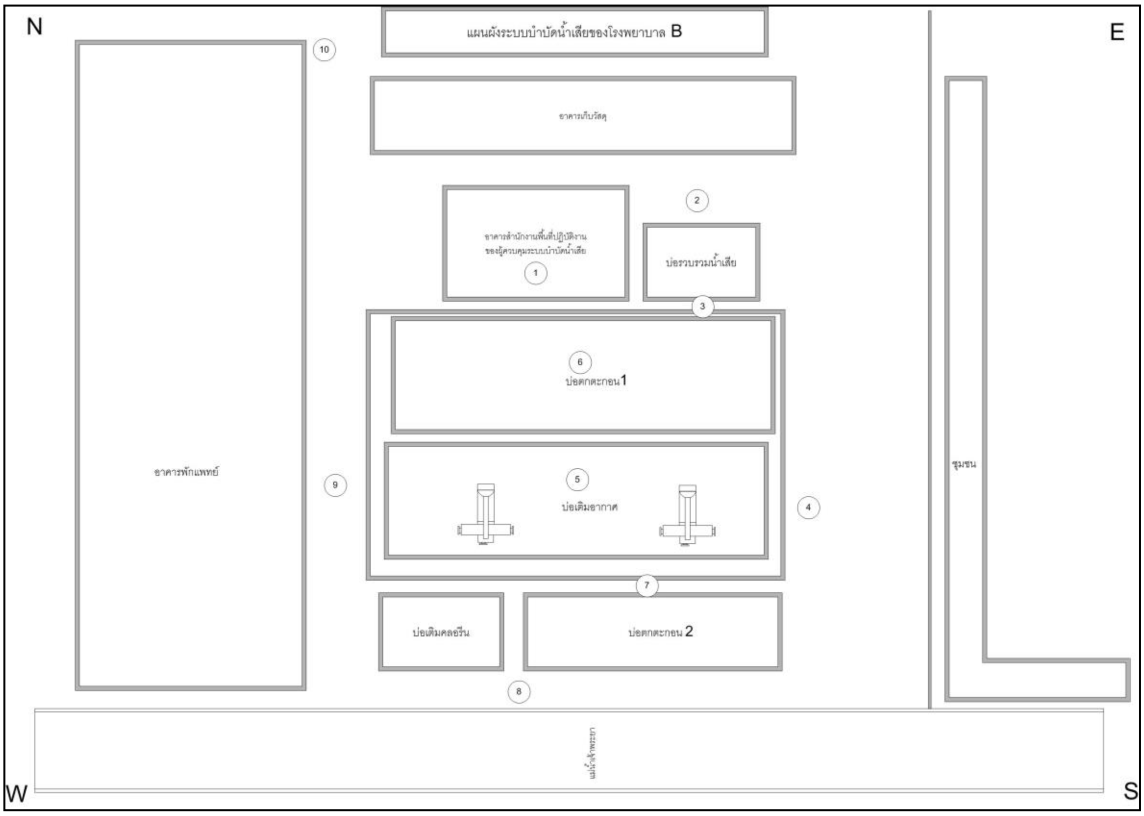

Fig. A.2 Sampling size layout hospital B.

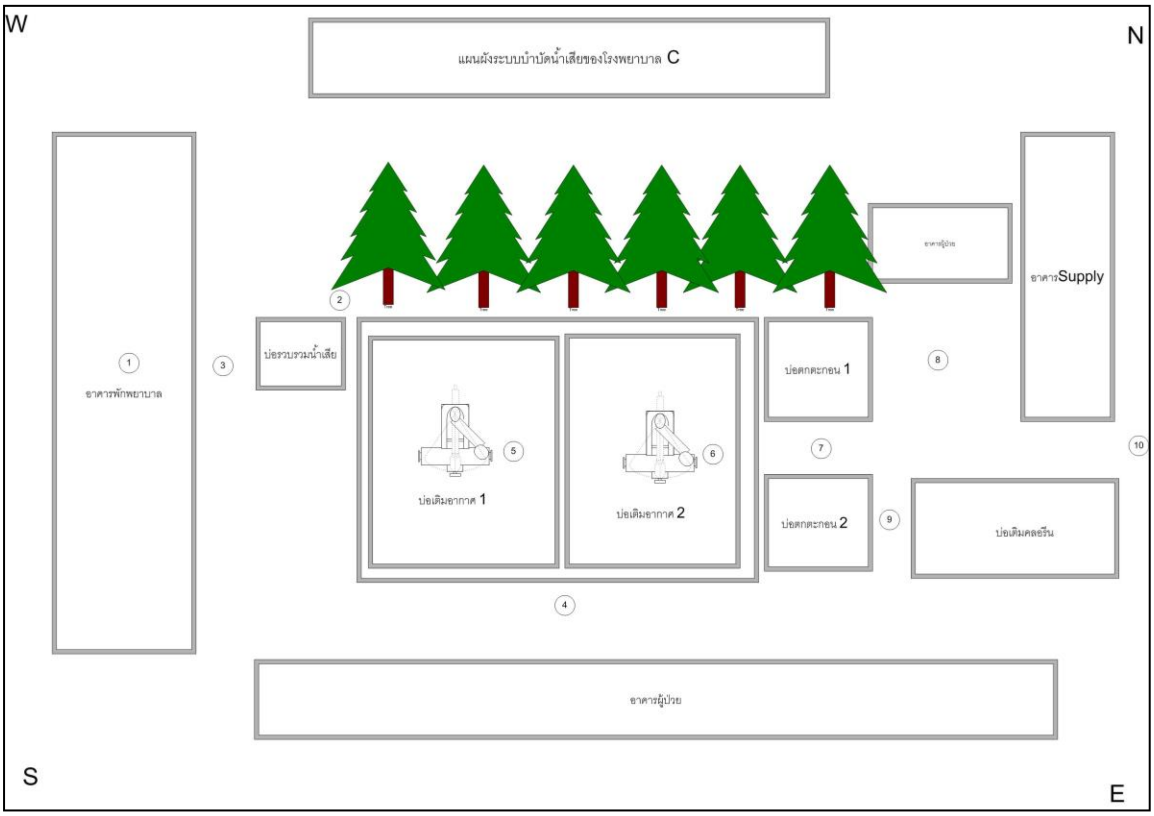

Fig. A.3 Sampling size layout hospital C.

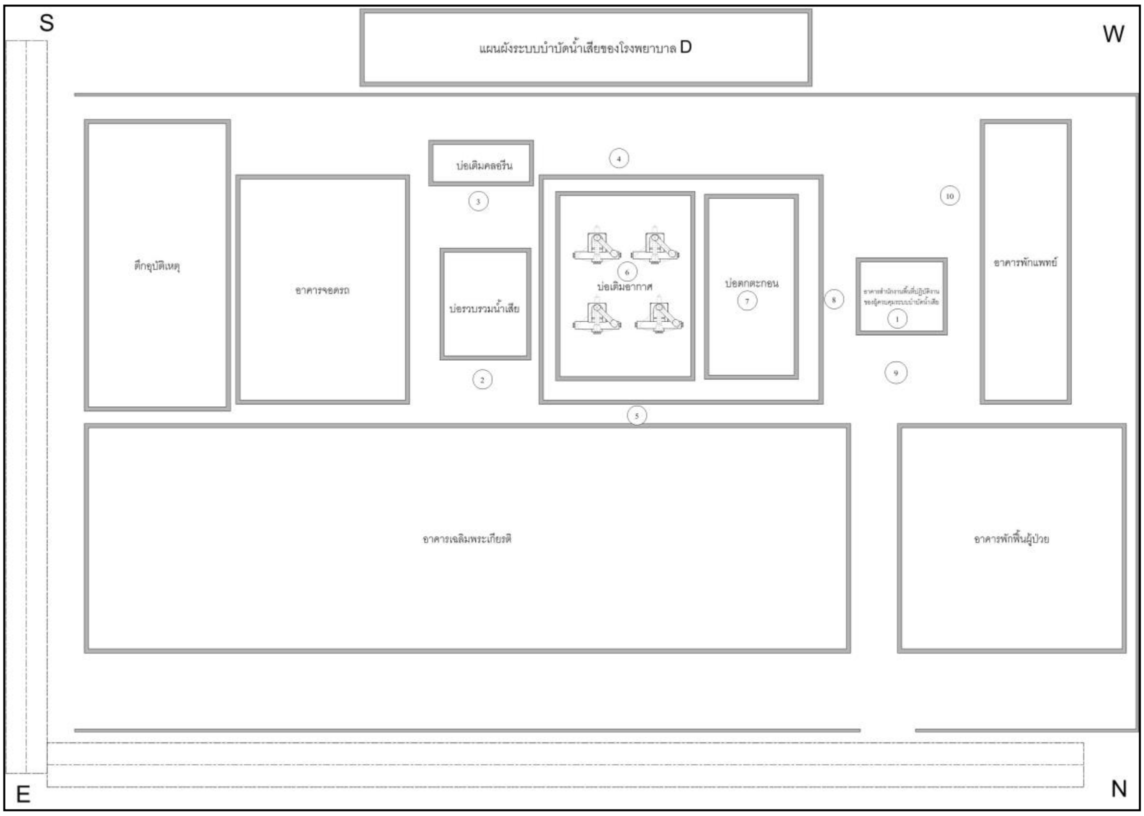

Fig. A.4 Sampling size layout hospital D.

Fig. A.5 Office building of hospital A.

Fig. A.6 Office building of hospital A.

Fig. A.7 Sediment Tank of hospital A.

Fig. A.8 Aerator Tank of hospital A.

Fig. A.9 Collecting in indoor office of hospital A.

Fig. A.10 Collecting in indoor office of hospital A.

Fig. A.11 Office building of hospital B.

Fig. A.12 Office building of hospital B.

Fig. A.13 The side of aerator tank of hospital B.

Fig. A.14 The top of aerator tank of hospital B.

Fig. A.15 Collecting in indoor office of hospital B.

Fig. A.16 Collecting in indoor office of hospital B.

Fig. A.17 Office building of hospital C.

Fig. A.18 Office building of hospital C.

Fig. A.19 The aerator tank of hospital C.

Fig. A.20 Sediment tank of hospital C.

Fig. A.21 The side of aerator tank of hospital C.

Fig. A.22 Collecting in indoor office of hospital C.

Fig. A.23 Office building of hospital D

.

Fig. A.24 Office building of hospital D.

Fig. A.25 Downwind of hospital C.

Fig. A.26 The top of aerator tank of hospital C.

Fig. A.27 Upwind of hospital C.

Fig. A.28 The top sediment tank of hospital C.

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