ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

ENUMARATION OF AIRBORNE MICROORGANISMS : EFFECTS OF OPERATIONAL FULL SCALE TREATMENT PLANTS IN ISTANBUL

M.Sc. Thesis by
Ayca ÇAKIR

Department: Environmental Engineering
Programme: Environmental Biotechnology

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M.Sc. Thesis by
Ayca ÇAKIR
(501031801)

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Supervisor (Chairman): Dr. Süleyman ÖVEZ (İTÜ)
Members of the Examining Committee: Prof. Dr. Dilek HEPERKAN (İTÜ)
Assoc. Prof. Dr. F. Gülen İSKENDER (İTÜ)

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Ayca ÇAKIR
(501031801)

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Tez Danışmanı : **Dr. Süleyman ÖVEZ (İTÜ)**
Diğer Jüri Üyeleri **Prof. Dr. Dilek HEPERKAN (İTÜ)**
Doç. Dr. F. Gülen İSKENDER (İTÜ)

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İÇİNDEKİLER

ABBREVIATIONS

ACGIH	:The American Conference of Governmental Industrial Hygienists
Bio-P	: Biological Phosphorus
CFU	: Colony Forming Unit
DAF	: Dissolved Air Flotation
EPA	: Environmental Protection Agency
LAF	: Laminar Airflow Cabinet
MPN	: Most Probable Number
NIOSH	: National Institution of Occupational Safety and Health
NYC-DOH	: New York City Department of Health
PCR	: Polymerase Chain Reaction
RODAC	: Replicate Organism Detection and Counting
WHO	: World Health Organization
WWTP	: Wastewater Treatment Plant

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SUMMARY

Several biological treatment plant in Istanbul surveyed to determine the numbers of culturable airborne microorganisms. These plants are; Ataköy, Tuzla and Pasakoy municipal wastewater treatment plants.

Each of these sources contains a vast number and variety of microorganisms, including pathogens. The air arround treatment plants usually contains high concentrations of airborne microorganisms. They can cause or trigger pulmonary-related diseases in animals and man, while many common pathogens of wastewaters and wastes are known to be transmitted aerially. In the same time some non-pathogenic microbes, can become opportunistic pathogens under certain conditions.

Because all the reasons mentioned above, lots of investigations are performed about airborne microorganisms in recent years. Environmental contamination sources like treatment plants, waste landfill sites, composting facilities etc. are investigated to monitor airborne microorganisms, health effects are identified and treatment methods evaluated. Furthermore, specific city air monitoring studies are conducted beside point source investigation studies. Monitoring airborne microorganisms emitted from industrial applications concerning occupational health issues is standed on the first rank. Especially hospitals, medical product production facilities, food production facilities are important working areas so these facilities has to monitor air quality because of the nature of their work and they has to ensure and maintain contamination free working environment to provide adequate product or service quality. Beside above applications, biological air quality monitoring is also important for the places such as residents, offices concerning sick building syndrome linked with ventillation, air conditioning systems, water lines etc. In the flood reclamation works, especially fungi monitoring results are used as important indicators to evaluate the effectiveness and appropriateness of the reclamation activities. In the recent years, biological weapon threat is getting primary concern so biological air monitoring is used for the detection of the attack and for the evaluation of

effectiveness and appropriateness of the reclamation activities. Certainly, studies on microbiological air quality monitoring will improve the knowledge because of a large number of application areas and importance of their health effects. While air quality indices and exposure levels are well defined in terms of certain chemical compounds, they are poorly defined regarding airborne contaminants of microbiological origin.

Wastewater treatment plants are investigated as dominant source of bioaerosols. Both point and area based evaluations are conducted. Total Bacteria, Total Coliform, Fecal Coliform and Total Fungi microbiological parameters and additionally wind speed, direction, temperature, humidity, weather situation are monitored. Samples are collected via using Merck Eco100 microbiological air sampler, these device uses 100 mm standard petri dishes and operates with Anderson principle.

Plate Count Agar for Total Bacteria, Endo Agar for Total Coliform, Violet Red Agar for Fecal Coliform, Saboroud Agar for Total Fungi are used.

Initially, sampling volume determination study was performed and 100 lt sampling volume is selected. Sampling points were selected to reflect the airborne contamination. In every treatment plant about 10 sampling points were selected. These sampling points have similar characteristics to provide comparison chance. These points are as follow : near coarse screen, fine screen, grit chamber, gravity settling, aeration tank, process tank, DAF, sludge tank, sludge dewatering, final clarifier units and near office, security building, at the plant boundary, 1 km away from plant boundary. As a result of this investigation, the highest numbers of airborne microorganisms are found in mechanically aerated units. After that, units such as grit chambers, aeration and process tanks investigated in detail.

Only the numbers of microorganisms that formed colonies were determined. These numbers are simple indicators of the microbial loads in the air, and they are useful to compare changes in the densities of airborne microorganisms and to detect locations that have high numbers. Obviously, lower microbial densities indicate that workers and people near the plant will be exposed to fewer airborne microorganisms, thereby reducing the potential for exposure to pathogens.

ÖZET

Bu çalışma süresince İstanbul'daki çeşitli arıtma tesisleri, kültürleştirilebilir havadaki mikroorganizma sayısını belirlemek amacı ile incelendi. Bahsi geçen tesisler; Ataköy, Tuzla ve Paşaköy Arıtma tesisleridir.

Bu arıtma tesisleri patojenleri de içeren çok sayıda ve çeşitte mikroorganizma ihtiva ederler. Tesisler etrafındaki havada genelde yüksek konsantrasyonda mikroorganizma bulunur. En çok bulunan ve sık rastlanan türlerinin hava yolu ile yayıldığı bilinmektedir ki havadaki bu mikroorganizmaların insanlarda ve hayvanlarda solunum yolu bağlantılı hastalıklara neden olduğu yada bu hastalıkların ortaya çıkmasını, yayılmasını hızlandırdığı bilinmektedir. Aynı zamanda patojenik olmayan mikroorganizmalar da bazı koşullarda patojen özellikler gösteren bir hale dönüşebileceklerinden çevre ve insan sağlığı açısından risk oluştururlar.

Yukarıda belirtilen tüm etkileri nedeni ile havadaki mikroorganizmalar özellikle son yıllarda gerek iç ortamda gerekse dış ortamda yürütülen birçok çalışmaya konu olmuştur. Çeşitli ülkelerde arıtma tesisleri, çöp depo sahaları, kompost tesisleri vb. gibi çevresel alanlardan yayılan mikroorganizmalar izlenmekte, sağlık üzerine etkileri değerlendirilmekte ve arıtma metotları araştırılarak denenmektedir. Bunun yanında dış ortam havası ile ilgili olarak kaynaksal etkilerin değil de direkt olarak dış ortam havasının takip edildiği şehre spesifik çalışmalar da yapılmaktadır. İş sağlığı ile ilişkili endüstriyel kaynaklardan yayılan havadaki mikroorganizmaların izlenmesi faaliyetleri ise üzerinde en çok çalışma yapılan konular arasında ön sırada yer almaktadır. Özellikle hastaneler, tıbbi üretim alanları, gıda imalathaneleri de yapılan işin doğası gereği ürün yada hizmet kalitesinin sağlanması için kontaminasyonun önlenmesi amacıyla mikrobiyolojik hava kalitesinin takip edildiği önemli çalışma alanlarıdır. Havalandırma, iklimlendirme, su hatları vb. kaynaklardan yayılan mikroorganizmalar ile oluşan hasta bina sendromu nedeni ile ise evlerde, ofislerde vb. yine bu tür çalışmalara sıkça rastlanmaktadır. Sel sonrası alanların ıslahı çalışmalarında özellikle havadaki mantar miktarının takibi söz konusu ıslah

çalışmalarının etkinliğini ve yeterliliğini belirlemek için önemli bir gösterge kabul edilmektedir. Son yıllarda artan biyolojik saldırı tehditleri neticesinde ise havadaki mikroorganizmaların tespiti ve yine etkilenen bölgelerin ıslahı çalışmalarında gösterge olarak mikrobiyolojik hava kalitesinin izlenmesi faaliyetleri yürütülmektedir. Şüphesiz uygulama alanlarının çokluğu ve sağlık üzerine etkilerinin önemi neticesinde mikrobiyolojik hava kalitesinin izlenmesi üzerine yapılan çalışmalar gün geçtikçe bu alandaki bilgi birikimini daha da arttıracaktır. Fakat günümüzde dünyada kimyasal maddeler için hava kalitesi indisleri ve maruziyet süreleri net bir şekilde tanımlanmış olmasına rağmen mikrobiyolojik kaynaklı hava kirleticileri iyi bir şekilde tanımlanmamıştır.

Bu çalışmada atıksu arıtma tesisi gibi dominant bir kaynak incelenmiş olup hem alansal hem de noktasal olarak değerlendirme yapılmıştır. Toplam Bakteri, Toplam Koliform, Fekal Koliform ve Toplam Mantar mikrobiyolojik parametreleri izlenmiş ilave olarak rüzgar hızı, yönü, sıcaklık, nem ve hava durumu bilgileri verilmiştir. Numuneler Anderson prensibine göre çalışan Merck Eco100 hava örnekleyicisi kullanılarak alınmış olup, bu cihaz 100 mm petri kabı ile numune almaktadır.

Toplam Bakteri için Plate Count Agar, Toplam Koliform için Endo Agar, Fekal Koliform için Violet Red Agar, Toplam Mantar için Saboroud Agar kullanılmıştır.

Öncelikle hava örnekleme hacmini belirlemek için Ataköy Atıksu Arıtma Tesisi'nde çalışma yapılmış olup, örnekleme hacmi 100 lt olarak belirlenmiştir. Ardından havadaki mikroorganizmaların yayıldığı kaynakları en iyi temsil edeceği düşünülen her bir tesiste benzer olarak ortalama 10'ar adet nokta seçilmiştir. Bu noktalar; kaba ızgara, ince ızgara, kum tutucu, ön çöktürme, havalandırma, proses tankı, DAF, çamur tankı, çamur susuzlaştırma, son çöktürme üniteleri ile güvenlik, ofis binası, tesis sınırı ile tesisten 1 km uzaklıkta referans alandır. Bu inceleme sonuçlarına göre mekanik havalandırma kullanılan ünitelerin daha çok mikroorganizma yaydığı tespit edilmiş olup ardından en çok mikroorganizma yayan kum tutucu, havalandırma ve proses tankları üzerinde yoğunlaşılarak daha çok numune alınmıştır.

Mikrobiyolojik olarak sadece havadaki mikroorganizmaların oluşturduğu koloni sayısı belirlenmiştir. Bu sayılar havadaki mikrobiyolojik yük için basit gösterge niteliğini taşımaktadırlar ve havadaki mikroorganizma yoğunluğunu karşılaştırmak ve yüksek miktarda mikroorganizma içeren alanları tespit etmek için kullanılabilirler. Bununla birlikte düşük mikrobiyolojik yoğunluk çalışanların ve yakın çevredeki

diğer insanların daha az sayıda mikroorganizmaya maruz kalmaları neticesinde patojenlere de maruz kalma potansiyellerinin düşük olduğunu gösterir.

1. INTRODUCTION :

The health and well-being of the public are affected by the physical, chemical and biological properties of the atmospheric environment. The quality of the atmospheric environment, however, is not easily defined or readily controlled, and poor air quality has been shown to cause adverse health effects. While air quality indices and exposure levels are well defined in terms of certain chemical compounds, they are poorly defined regarding airborne contaminants of microbiological origin. As a generic class of airborne pollutants, particulate matter usually ascociated with compounds of biological origin is often termed “bioaerosol”. This definition includes all airborne microorginisms regardless of viability or ability to be recovered by culture; it comprises whole microorganisms as well as fractions, biopolymers and products from all varieties of living things (ACGIH, 1999).

Atmospheric environment contains large numbers of airborne microorganisms. Many microorganisms: bacteria, fungi, viruses, are airborne in the environment and at the workplaces. They can be responsible for adverse health effects like infection or immunoalergic disorders. Prevention of occupational diseases requires the measurement of air quality, and more particularly bioaerosol concentration (Fabries, J.F. et al., 2001). Consequently their estimation is important for use as an index of cleanliness for atmospheric environment. Knowledge of the incidence of airborne microorganisms at outdoor is important for their possible correlation to infectious diseases or associated allergic reactions (Fink et al., 1971). Knowing the types of microorganisms and controlling them in the atmospheric environment may play a significant role in preventing many infectious diseases.

The aim of this bioaerosol investigation study are to assess the cause, nature and extent of microbial contamination, assess the risk of adverse effects on the health of public,. manage the microbial problems; and providing data to help wastewater treatment plant workers for returning the contaminated areas to a satisfactory level of performance. Therefore, was to compare the numbers and types of airborne microbial

populations present around the different units of municipal wastewater treatment plants in Istanbul and to possibly set standards for tolerable levels of contamination.

During this study, measurements of the concentrations of airborne material near dominant sources are reviewed for both area sources, and for point sources such as sewage and wastewater treatment work.

2. LITERATURE

2.1.BIOAEROSOL DESCRIPTION

Bioaerosols are defined as “aerosols comprising particles of biological origin or activity which may affect living things through infectivity, allergenicity, toxicity, pharmacological or other processes” (Hirst, 1995).

Bioaerosols can consist of bacterial cells and cellular fragments, fungal spores and by-products of microbial metabolism, which can be present as particulate, liquid or volatile organic compounds (Stetzenbach, L.D. et al., 2004). Bioaerosols in occupational and residential environments are generally complex mixtures that may include microorganisms (viable and dead) as well as their cell fragments (e.g., cell wall fragments and flagella) and metabolites (e.g. mycotoxins and volatile organic compounds) (Agranovski, I.E. et al., 2001).

Stetzenbach, L.D. et al. (2004) cite Cox, C.S. and Wathes, C.M. as stating that the particulate in a bioaerosol is generally 0.3–100 μm in diameter; however, the respirable size fraction of 1–10 μm is of primary concern. Lighthart, B. (cited by Stetzenbach, L.D. et al., 2004) stated that the single bacterial cells range in size from 0.5–2.0 μm and are commonly spheres (cocci), rods (bacilli) or spirals, but airborne microorganisms are often present as aggregate formations of larger particles. Bioaerosols that range in size from 1.0–5.0 μm generally remain in the air, whereas larger particles are deposited on surfaces. Physical and environmental factors affect the settling of aerosols. Air currents, relative humidity and temperature are the most important environmental parameters affecting bioaerosol settling. The most significant physical parameters are particle size, density and shape (Mohr, A.J., 1994).

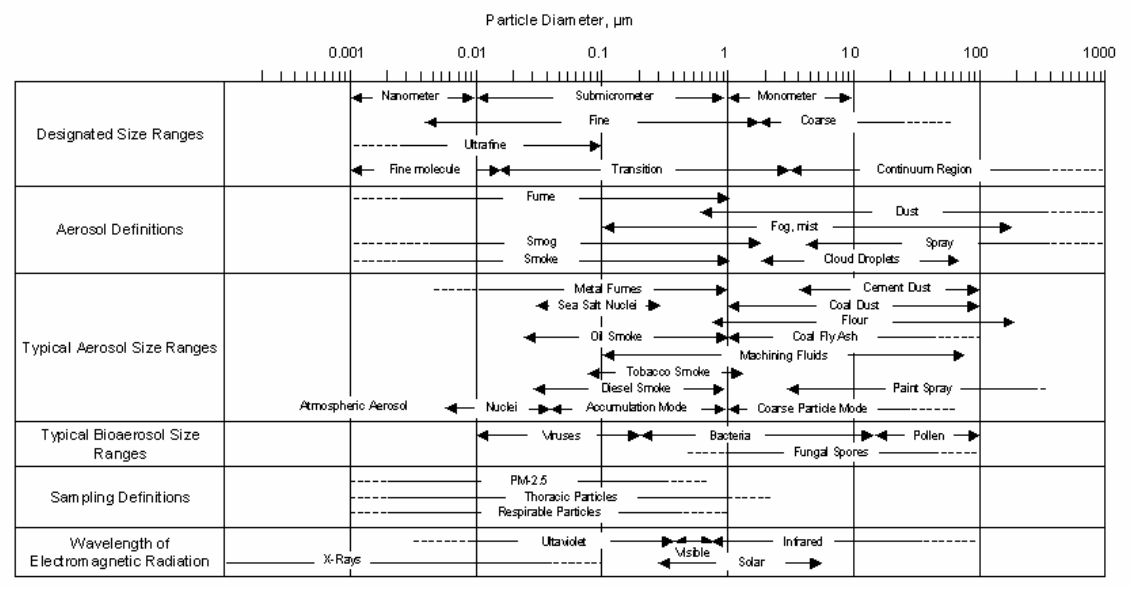


Figure 2.1 : Typical size ranges and definitions of aerosols (Hinds, 1999)

Airborne biological particles range in aerodynamic diameter between 0.01 and 100 µm (ACGIH, 1999). In many environments, airborne bacteria, fungi and their fragments may fall Into a respirable size range that can penetrate deep into human lungs (< 10 µm) (Gorny et al., 2002).

Bioaerosols usually exist in the air as small particles like aerosol, spore or microorganism binding dust, but most of them will drop on the ground soon because of their own weights. However, they are floating in the air for hours if their diameters are about 1-3 µm and if they are dried states (Makino, S. and Cheun, H., 2001).

2.1.1. Types of Bioaerosols

Bioaerosol can be classified into the following groups; animals, bacteria, fungi, plants, protozoans and viruses (Warden, P, 1995).

- *Animals* of all types can contribute to human allergic reactions and air quality problems. Animal by-products, such as dust mite fecal material have been shown to promote allergic responses in some people.
- *Bacteria* particularly, Gram negative bacteria, have been associated to a variety of air quality bioaerosol problems. Typical diseases include pneumonia, allergic reactions, chronic bronchitis, Legionnaire's disease, hypersensitivity pneumonitis, and humidifier fever.

- *Fungi* are the most common type of organism related to air quality problems because of their ability to colonize, multiply and disseminate (via spores) throughout the air environment. Health issues related to fungi include pathogenic and opportunistic pathogenic fungi, sensitivity to chemical by-products of fungi, and allergic reactions to the spores themselves.
- *Pollen* used by plants to reproduce causes considerable discomfort to many people. Typically contaminants of this sort are not major problems in facilities with adequate HVAC systems.
- *Protozoans* have also been implicated in indoor air quality problems. Although most of these organisms are too large to be aerosolized, they may contribute to the amplification of other microorganisms. For example, free living amoebae may harbor legionella bacteria, shielding the bacterial target from a dose of biocide.

  Viruses are not considered to be living organisms, as they lack the systems required for independent reproduction and consist of only genetic material (DNA or RNA) in a protein shell. However, most groups of viruses are capable of respiratory transmission and cause a variety of human diseases and therefore are a component of indoor air quality.

2.2.HEALTH EFFECTS

Biological hazards may be equally diverse, because the different numbers and types of biological agents that may be presented. Many kinds of microorganisms exist in the air, which are mostly non-pathogenic to humans. However, though it may be artificial or rarely occur, pathogenic microbes sometimes exist in the air and cause respiratory infection (Makino, S. and Cheun, H., 2001).

Bioaerosols are known to cause various health effects, including infections (e.g., acute viral infection, legionellosis, or tuberculosis), hypersensitivity (allergy; e.g.; allergic rhinits, astma, or hypersensitivity pneumonitis), toxic reactions (e.g.; humidifier fever), irritations (e.g.; sinusitis or conjunctivitis). he infectious opportunistic pathogens (viruses, bacteria and fungi) and, thus, an exposure to infectious microorganisms and related health risk are determined by their concentration in air. The allergenic, toxic and inflammatory responses, on the other

hand, can be caused by both viable and non-viable components of the bioaerosol. Consequently, an exposure to such bioaerosols and the ascociated health risk are determined by the total (viable and non-viable) concentration of bioaerosols (Agranovski, I.E., et al. 2003).

Bioaerosols in occupational and residential environments are generally complex mixtures that may include microorganisms (viable and dead) as well as their fragments (e.g., cell wall fragments and flagella) and metabolites (e.g., mycotoxins and volatile organic compounds). They are known to cause various health effects, including infections (e.g., acute viral infection, legionellosis, or tuberculosis), hypersensitivity (allergy,; e.g., allergic rhinitis, asthma, or hypersensitivity pneumonitis), toxic reactions (e.g., humidifier fever), irritations (e.g., sore throat), and inflammatory responses (e.g., sinusitis or conjunctivitis) (Crook, B. and Olenchock, S.A., 1995).

The infectious effects can be caused only by viable pathogen or opportunistic pathogens (viruses, bacteria, and fungi) and, thus, and exposure to infectious microorganisms and the related health risk are determined by their concentration in air.

Their allergenic, toxic and inflammatory responses, on the other hand, can be caused by both viable and non-viable components of the bioaerosol.

Consequently, an exposure to such bioaeorols and the associated health risk are determined by the total (viable and non-viable) concentration of bioaeorols.

Nevertheless, since the adjuvant effects of some of the constituents of bioaerosols on the human health may be synergistic and the exact pathological mechanisms of particular bioaerosol components on the health effects are still under investigation, it is general practice to enumarate both the viable and total concentrations of airborne microorganisms. In addition to the enumaration of the microorganisms, species information is important when comparing indoor air sampling with outdoor controls and when assessing airborne microbial species that can be specifically linked with the disease. Cultivation analysis is typically used for an identification of the microbial species, until other modern identification techniques become routinely available. Maintaining microbial viability (culturability) during sampling is

therefore essential for the detection and identification of the targeted microbial species with the traditional cultivation methods.

Individual exposure to bioaerosols can best be evaluated by the use of personal aeorol monitors, as these samplers track the effects of human time-activity patterns.

2.3.REGULATORY LIMITS

The literature concerning human bioaerosol exposures and associated regulatory limits is tenuous. At present, neither the US Environmental Protection Agency (EPA) nor the National Institution of Occupational Safety and Health (NIOSH) have proposed concentration limits for bioaerosols. One of the earliest guidelines was proposed in 1946 which suggested that no more than 0.1–20 colony forming units (CFU)/ft^3 should grow in 24 h in operating theatres. The American Conference of Governmental Industrial Hygienists (ACGIH) reported interim indoor bioaerosol exposure guidelines based on culturable levels of bacteria and fungi, but these guidelines have been repealed since 1999. Those guidelines recommended that less than 100 CFU/m^3 was an acceptable level (ACGIH, 1989).

The Health and Welfare Department in Canada proposed the following guidelines: (1) 50 CFU/m^3 of one species of fungi warrants immediate investigation; (2) the presence of certain fungal pathogens is unacceptable; (3) 150 CFU/m^3 of mixed species is normal; and (4) up to 500 CFU/m^3 is considered acceptable if the species present are primarily *Cladosporium* (WHO, 1990). The European Union also suggested bioaerosol concentration exposure thresholds in terms of CFU, suggesting guidelines for residential and industrial environments. More recently, Gorny and coworker reviewed European literature databases on residential indoor air quality and proposed the following residential limit values: 5 × 103, 5 × 103 CFU/m^3, and 5 ng/m^3 for airborne fungi, bacteria and bacterial endotoxin, respectively; the presence of pathogenic fungi is considered unacceptable in any concentration (Gorny, R.L. and Dutkiewicz, J., 2002). In 1994, the New York City Department of Health issued guidelines for assessment and remediation of indoor fungal contamination. This report qualified recommendations in the context of biological indoor air quality problems with the statement “It is not possible to determine “safe” or “unsafe” levels of exposure” (NYC-DOH, 1994). To determine the presence of significant indoor

microbiological sources, these guidelines also recommended comparisons of the species recovered from standard plate counts. In addition to comparing the microorganism concentrations recovered from parallel air samples collected indoors and outdoors. These recommendations have become standard for many other organizations.

Most of these guidelines are based on baseline (bio)aerosol concentrations, without taking into account effects on human health (Rao et al., 1996). In addition, most studies have proposed threshold bioaerosol concentrations based on culturing assays. Organizations such as NATO and WHO have concurred that, there is a need to develop more accurate and robust methods for characterizing biological aerosols (WHO, 1990). Since many bioaerosol associated diseases are not dependent upon infection to induce adverse health effects, It is important to quantify all microbial cells that are suspended in the air, as well as differentiating between those that are metabolically active, those that are culturable, and those that are non-viable (Hernandez et al., 1999).

In Turkey, Preventing Exposure to Biological Agents regulation are effective. But that regulation doesn't cover the limit values for microbiological paramethers, only classifies the working environment into hazard classes and identifies the preventive measures which had to be taken.

2.4.BIOAEROSOL EVALUATION

Bioaerosols are collections of airborne biological material. Components of the airborne material might result in health effects to exposed individuals in both the outdoor and indoor environment (Cox, C.S. and Wathes, C.M., 1995). Stetzenbach, L.D. et al. reported that the sampling and analysis of airborne microorganisms has received attention in recent years owing to concerns with mold contamination in indoor environments and the threat of bioterrorism. Additionally, fungal spores, mycotoxins, endotoxin and other non-infectious agents released into the air in buildings are of indoor air quality concern (Buttner, M.P. and Cruz, P., 2004). The quantitative assessment of bioaerosols is important in a number of industrial and environmental applications. Measurements to aid the control of airborne infection, detection of the release of potentially harmful microorganisms from bio-processing equipment and monitoring the exposure of workers and animals to bioaerosols are

examples of situations where different concentrations of microorganisms and varying ambient conditions may be expected (Grinshpun, S.A. and Clark, J.M., 2005).

Measurement of microorganisms relies upon collection of a sample into or onto solid, liquid, or agar media followed by microscopic, microbiologic, biochemical, immunochemical or molecular biological analysis (Breeding, D.C., 2003).

While numerous techniques have been either specifically developed or adopted for detecting and enumerating airborne bioaeosols, the measurement and characterization of bioaerosols remains a very challenging problem (Grinshpun, S.A. and Clark, J.M., 2005). The variability of the measured microorganism concentration largely depends on the sampling technique used and on the analytical method. (Ambroise, D. et al., 1999). However, accurate field-compatible methodologies for the detection, quantification, and identification of various types of bioaerosols are critical for future progress in the entire bioaerosol research area (Grinshpun, S.A. and Clark, J.M., 2005).

Bioaerosols may exist in both *viable* (living) and *nonviable* states. Generally, there are two approaches for evaluation of microbial exposure: *culture methods* and *non-culture methods*. Most methods attempt to sample for only viable particles because these can be cultured so that they multiply, making identification easier. Counting culturable microorganisms is a very sensitive quantification method that also permits identification of species. However, viable sampling is limited to short sampling times (to reduce loss of viability) and may introduce significant measurement error. Although dead or non-culturable microorganisms and specific microbial components are not detected by culture methods, bioaerosols in the nonviable state may have potential toxic or allergic properties. Spores, which can be formed by fungi and by certain bacteria, can be both viable and nonviable and are capable of causing disease in both forms (Breeding, D.C., 2003).

Non-culture methods attempt to enumerate organisms without regard to viability, using microscopy for counting spores or cells. They allow full work shift measurements but have specific problems, such as a limited potential for quantitative identification and low counting accuracy (Breeding, D.C., 2003).

Advanced methods such as PCR-based technologies, FISH, and immunoassays have opened new avenues for detection and speciation regardless of whether organisms

are culturable. Also, specific bioaerosol associated agents can be measured using specific immunoassays, other bioassays, or gas chromatography and mass spectrophotometry. These agents may either be directly pathogenic (such as allergens, bacterial endotoxin, and fungal mycotoxins) or may be general markers of exposure (such as ergosterol, fungal extracellular polysaccharides). Unfortunately, there are no currently available methods for many bioaerosols (Breeding, D.C., 2003).

Microorganisms are notoriously difficult to assess accurately under such variable conditions and no single assay method is suitable for all applications; rather the method needs to be tailored to the application of interest. Problems are compounded by the differences in assay method (such as the type of media used for culturable counts) or sampler type selected, making the interpretation of the results difficult. An understanding of the airborne behaviour of microorganisms over a range of environmental conditions is vital if procedures are to be defined and recommended for the handling, sampling and assessment of bioaerosols (Grinshpun, S.A. and Clark, J.M., 2005).

2.5.BIOAEROSOL SAMPLING

Bioaerosol sampling is conducted in an attempt to discern whether the agents of concern are being generated within an atmospheric environment. The characteristics of viable bioaerosol agents require specialized sampling instruments in order to preserve the organisms for laboratory culture and evaluation. Their temperature, moisture, nutrient needs, and their relative fragility are primary considerations when selecting sampling instrumentation (Breeding, D.C., 2003).

2.5.1. Bioaerosol Sampling Methods

Methods for collecting bioaerosol samples in the atmospheric environment are classified as *passive* or *active*. Passive air sampling methods are straightforward and can be done by simply setting out plates containing appropriate culture media. Such settling plates may be compromised by exogenous air currents and by contamination from external and human origins. Passive methods, moreover, are not as effective as more active sampling methods (Breeding, D.C., 2003).

Active sampling methods use traditional sampling trains consisting of a personal air sampling pump connected by tubing to appropriate media, along with a flow calibration device. Specialized instruments may also be available (Breeding, D.C., 2003).

Active air sampling instrumentation falls into two main categories, inertial impactors and a group consisting of impingers, rotating impactors, and filters (Breeding, D.C., 2003).Most frequently used for sampling airborne microorganisms have been impaction devices that collect directly onto agar media, impingers that collect into liquid and filtration devices (Crook, B. and Sherwood-Higham, J.L., 1997). Most of them allow the direct collection of microorganisms onto agar media allowing further cultivation of microorganisms (bacteria, fungi) expressed in colony forming units (CFU/m^3) of air (Fabries, J.F., et al., 2001).

Most active air sampling methods rely on impaction. The slit sampler and the cascade impactor are examples of inertial impactors and are typically used for screening evaluations because they have short sampling times and accommodate a wide variety of organisms to be collected. Collection can be performed over a short sampling time, because the media can be examined directly under a microscope or a variety of strips or plates containing different culture media can be used sequentially. Impingers collect material from the air in a liquid medium that can be transported to the laboratory for appropriate analysis. Filter instruments collect samples directly onto filter paper media (Breeding, D.C., 2003).

There is now agreement that the sampling of bioaerosols, particularly where such sampling is targeted towards health effects, should be based on the particle size selective criteria (in particular, the inhalable convention), now defined by ACGIH, IS0 and CEN. (Aitken, R.J. and Lowrie, S.J.R., 1998).

2.5.1.1.Impaction Samplers :

Stetzenbach, L.D. et al. reported that impaction samplers that deposit airborne particulate onto a semi-solid agar surface are used with culture-based analysis. The Andersen single-stage impactor sampler (Andersen Instruments, Smyrna, GA), which is routinely used for the collection of culturable airborne bacteria and fungi, is operated at an air flow rate of 28.3 L/min. Collection of a 2 min sample and enumeration of a single colony in an air sample corresponds to a lower detection

limit of 18 colony forming units per cubic meter of air sampled (CFU/m³). The upper quantitation limit of this sampler is 104 CFU/m³, owing to space limitations on the agar collection surface, but considerable enumeration error is introduced at higher concentrations as multiple cells are deposited on the same location of the agar surface. When the sampling time is increased beyond 5 min the agar surface dries, thereby decreasing the physical collection efficiency of airborne particles owing to particle bounce and decreasing the viability of the bacterial cells due to desiccation (Buttner, M.P., et al., 2002). Impaction samplers that deposit airborne particulate onto an adhesive-coated microscope slide rather than agar are used with light microscopy analysis to measure both viable and non-viable organisms; however, this methodology is usually limited to the measurement of pollen grains and fungal spores with identification to the genus level. (Radosevich J.L., et al., 2002).

2.5.1.2.Impingement Samplers :

Impingement samplers collect airborne cells and other particulate into a liquid (Buttner, M.P., et al., 2002). Commonly used impingement samplers are operated at an air flow rate of 10–12 L/min, but high velocity samplers have been developed for sampling larger volumes of air over extended sampling times (Radosevich J.L., et al., 2002). Impingement collection permits processing of the sample by dilution or concentration to maximize accuracy in quantitation. Aliquid sample can also be used with a variety of analytical methods, including culture, microscopy, immunoassay, flow cytometry and molecular methods (Buttner, M.P., et al., 2002). Extended collection times with impingement sampling can result in increased sampling stress, thereby decreasing the viability of the collected bacteria (Buttner, M.P. and Stetzenbach, L.D.,1991).

2.5.1.3.Filtration Sampling :

Filtration sampling consists of the collection of bioaerosols by passing air through a porous filter material. Filtration sampling results in desiccation of vegetative bacterial cells; therefore, this technique is generally used for sampling of airborne dust, fungal spores and polen. Settling or gravity plates do not result in a representative sample of airborne cells, because of the differential settling of particles from the air; for this reason the method is not recommended for the determination of airborne microbial populations (Crook, B., 1995).

2.5.1.4.Surface Sampling :

Air sampling is traditionally used to determine the concentrations of airborne contaminants and to evaluate the risk of exposure to individuals (Buttner, M.P. and Stetzenbach, L.D.,1991). Sometimes, beside air surface sampling can be used to provide assurance that an area is free of biological contamination, because organisms may become re-aerosolized from surfaces during routine activity. Therefore, surface sampling in addition to air sampling is used to locate areas of contamination and in identifying the source(s) of biocontamination. Surface sampling is also used in determining the effectiveness of remediation and clean-up of contaminated environments.

2.5.1.5.Contact Sampling :

The convex sampling surface of agar-filled RODAC (Replicate Organism Detection and Counting) plates is commonly used as a contact sampling method in hospital infection control to validate the efficacy of disinfection of surfaces, but sterile swabs are more often used to sample hard, smooth surfaces in buildings (Buttner, M.P. et al, 2001)

2.5.1.6.Collection Bags of Filter Cassettes :

Vacuuming with dust sample collection bags or filter cassettes is used to sample porous (e.g. carpeting, upholstery and clothing) and non-porous (e.g. flooring, horizontal surfaces and furnishings) materials indoors. Vacuuming can sample large surface areas and be used with a variety of analysis methods after processing the collected material with a buffer solution. (Stetzenbach, L.D. et al., 2004)

2.5.1.7.PCR

Stetzenbach, L.D. et al. reported that traditionally, the detection and enumeration of airborne microorganisms has been conducted using light microscopy and/or culture-based methods; however, these analyses are time-consuming, laborious, subjective and lack sensitivity and specificity. The use of molecular methods, such as quantitative polymerase chain reaction amplification, can enhance monitoring strategies by increasing sensitivity and specificity, while decreasing the time required for analysis.

2.5.2. Considerations for Bioaerosol Sampling

A number of bioaerosol sampling methods are available. The selection of the most appropriate exposure assessment method(s) for bioaerosols is highly dependent on the specific goals of the evaluation and the specifics of the affected environment (Breeding, D.C., 2003).

Estimation of the airborne concentration of any material from a sample collected requires that the efficiency of all of the steps in the process from sampling to analysis are known. For estimation of bioaerosol concentrations, there are four steps, *aspiration, transmission, collection* and *microbiological analysis*, each having an associated efficiency (Aitken, R.J. and Lowrie S.J.R., 1998).

The performance of samplers depends on their inlet efficiency and on the physical and biological collection characteristics. The differences in physical and biological collection efficiencies of bioaerosol samplers often reflect different particle collection mechanism employed as well as the collection media and sampling time. The physical sampling eficiency is defined as the product of the aspiration, transmission and collection efficiencies. (Grinshpun, S.A. et al., 2002).

Following statements highlight the importance of the different factors which combine to define the overall efficiency of a bioaerosol sampler (Grinshpun, S.A. and Clark, J.M., 2005). Grinshpun, S.A. and Clark, J.M. are cited that four important aspects were considered by Nevalainen et al. (1992):

- sampling efficiency is a measure of how well the inlet of a sampler draws in particles without being affected by particle size, shape velocity or travel direction,
- collection efficiency is a measure of how well the sampler deposits the particles without being affected by their physical properties,
- bioefficiency is a measure of how well the sampler maintains the microbial culturability and prevents cell damage during sampling,
- assay efficiency is a measure of how well the microorganisms can be detected following possible damage during aerosolisation and capture.

In the same time, assessment of bioaerosol exposure offers challenges distinct from those for inorganic aerosols and chemical agents (Breeding, D.C., 2003).

The nature of the sample will affect the choice of sampling method. For example, collecting airborne particles by filtration onto polycarbonate membranes probably provides the simplest sampling method, but dehydration can decrease the viability of some bacterial cells. However, the method is applicable if more robust spore-forming bacteria or fungi are to be analysed. Filtration could also be best where the analytical method does not rely on viability of the collected microorganism, such as direct microscopic counting or assay of a biochemical marker. Filtration is often the sampling method chosen for collection of non microbiological bioaerosols such as proteinaceous aeroallergens. However, in some instances the allergenic protein may be denatured by the dehydration stresses of collection on filters and collection into liquid may be preferable (Griffin et al., 1994).

Users' knowledge of the strengths and imitations of each sampling method is crucial to achieving valid results and to implementing safe, healthful, and effective control strategies (Breeding, D.C., 2003).

2.6.ENUMARATION OF BACTERIA

Microorganisms with prokaryotic cells include the archaebacteria and the eubacteria. These prokaryotic cell is structurally not as complex as the eukaryotic cell. However, all living systems are extremely complex. Eubacteria and archaebacteria, like all other living organisms, must meet their metabolic activities, replicate their hereditary (genetic) information, and reproduce. Failure to accomplish an yor all of these taks redults in death (Atlas, R.M., 1995).

To assess rates of bacterial reproduction, it is necessary to determine numbers of bacteria. Various methods can be employed for enumarating bacteria. These include viable plate count, direct count, and most probable number (MPN) determinations (Atlas, R.M., 1995).

2.7.ENUMARATION OF FUNGI

The eukaryotic microorganisms include the fungi, algae, and protozoa. These microorganisms, like the higher plants and animals, have eukaryotic cells. The

evolved along different lines of descent, apparently based on how they obtain nutrition. The algae carry out photosynthesis, obtaining energy from light and carbon from inorganic carbon dioxide for cell groth. The fungi absorb organic nutrients that they use to generate cellular energy and cell constituents. The protozoa tend to engulf nutrients, sometimes growing on other cells (Atlas, R.M., 1995).

Like the bacteria, the fungi are extremely diverse. Unlike bacteria, however, fungi are composed of eukaryotic cells. Most fungi have cell walls, which most often chain chitin, the substance that makes up insect skeletons and crab shells. These cell walls hep protect the cells against physical damage and chemical attack. Some fungi – yeasts- are primiraly unicellular. Others, call filamentous fungi or molds, from tube-like filaments called hypae. Some hypae are coenocytic, meaning they lacek cross-walls to seperate cells; coencytic hypae are mutinucleate (Atlas, R.M., 1995).

Hypae, which are composed of many cells, can form integrated masses called mycelia. Mycelia are the visible structures seen when molds grow on bread and other substrates. In some cases, elongation of hypae occurs without forming seperate cells. Long, multinucleate, fungal hypae develop. More commonly, seperate cells are formed by branches and crosswalls as the hypae grow. The crosswalls are called septa. Even when crosswalls form cellular materials flow through pores in the septa.

Fungi obtain their energy from the metabolism of organic compounds. They generally absorb nutrients from their surroundings, often from plant materials. In nature, fungi are very important decomposers. They cause, for example the decay of dead logs. Unfortunately many are also plant pathogens, causing great losses of agricultural crops. We sometimes use chemical fungicides to protect many cultivated plants. A few also cause human diseases such as athlete's foot, histoplasmosis, coccidioidomycosis, and yeast (Candida) infections (Atlas, R.M., 1995).

The classification of fungi is based primarily on their sexual reproductive spores. Some sexual spores of fungi are formed within a specialized structure known as the ascus. Such spores are called as ascospores and the fungi that produce them are called ascomycetes. Another major group of fungi, the basidiomycetes, produce sexual spores on a specialized structure known as the basidium. A mushroom is such a basidium. The spores produced by basidomycetes are called basidiospores. Other fungi, known as the deuteromycetes or fungi imperfecti, have no known sexual

reproductive phase. As far as we know, they are restricted to asexual means of reproduction. The fungi imperfecti include Penicillium and Aspergillus, two of the more common fungi that we may observe growing on foods such as bread (Atlas, R.M., 1995).

To distinguish among species of yeasts, we employ a few morphological (structural) observations and numerous metabolic characteristics. The procedure for identifying the unicellular yeasts is very similar to that employed for identifying bacteria. For the filamentous fungi, on the other hand, we rely almost entirely on morphological observations. We use the same basic approach used in identifying plants. Mushroom-producing fungi, for example, are identified on visiul apperance. Great care should be taken in identifying mushrooms. Some mushrooms are edible but others that may look quite similar are deadly poisonous. Even experts have sometimes been foolod and have died after eating mushrooms that they improperly identified (Atlas, R.M., 1995).

Viable plate count methos can be employed for enumarating fungi.

2.8.VIABLE COUNT PROCEDURES

Not only it is important to see microbes, it is also often necessary to know the number or mass of cells. To determine how many are present, a number of techniques are available, most probable number, direct microscopic counts, automated cell counters, plate counts, and many indirect methods as well (Kelley, S.G. and Post, F.J., 1989).

The viable plate count method is one of the most common procedures for the enumaration of bacteria. In this procedure, serial dilutions of a suspension of bacteria, fungi etc. are plated onto a suitable solid growth medium and after a period of incubation during which single cells multiply to form visible colonies) the number of colonies are counted or enumarated. (Atlas, R.M., 1995)

Frequently, for water and wastewater applications the suspension is spread over the surface of an agar plate containing growth nutrients (surface spread technique). Alternatively, it can be mixed with the agar while it is stil in a liquid state and poured into the plate (pour plate technique) (Atlas, R.M., 1995). For bioaerosol applications, procedure is to take air directly on the plate.

The plates are incubated to allow the bacteria, fungi etc. to grow and form colonies. The formation of visible colonies generally takes 16 to 24 hours.

It is assumed that each colony arises from an individual cell. By counting the number of colonies that develop, the colony forming units (CFUs) and by taking into account the dilution factors, the concentration in the original sample can be determined. Preferably two or three plates are counted to determine numbers in a sample (Atlas, R.M., 1995).

Each plate counted should have 30 to 300 colonies.

If numbers in a sample are low, it is sometimes necessary to filter the suspension to concentrate the cells by collecting the cells on a membrane fitler for water and wastewater applications. The typical membrane filter for collecting bacterial cells is made of nitrocellulose or cellulose acetate and has a pore size of 0.2 to 0.45 μm, which is small enough to trap most bacterial cells. The membrane filter with the trapped bacteria, fungi etc. is then placed onto a suitable medium so that bacterial reproduction can occur, and the colonies that develop on the filter are counted. For bioaerosol application, sampling volume should be choosen bigger to eliminate the problem (Atlas, R.M., 1995).

Countable plates are those having between 30 and 300 colonies. Less than 30 colonies is not acceptable for statistical reasons and more than 300 colonies on the plate are likely to produce colonies too close to distinguish as individual CFUs. Such samples are noted as TNTC (too numerous to count) (Atlas, R.M., 1995).

A major limitation of the viable plate count procedure is that it is selective. There is no single combination of incubation conditions and medium composition that permits the growth of all types. The nature of the growth medium and incubation conditions determine which type can grow and thus be counted. Viable counting measures only cells that are capable of growth on the given plating medium under the set of incubation conditions that are used. Sometimes cells are viable but nonculturable unless rigorous steps are taken to acclimate the microorganisms to laboratory culture conditions. The viable plate count relies on the reproduction of individual cells to form visible colonies, which are counted to enumerate numbers of bacteria in a samle. Another problem and source of possible error associated with this technique is in the enumaaration of bacteria that growth in chains or clumps that

are hard to disperse. For example, a chain containing ten attached cells will grow into one colony instead of ten. Therefore using the viable plate count method to measure numbers of bacteria that tend to remain attached to one another can lead to errorenously low values (Atlas, R.M., 1995).

2.9.SUMMARY OF THE SIMILAR STUDIES

There are several bioaerosol monitoring studies performed both indoor and outdoor.

Indoor studies was performed especially in healthcare facilities, schools, special industries, flood reclamated areas etc. However our study is conducted for monitoring bioaerosols at outdoor, one similar study from Turkey is also summarised below.

There is also one study for microbiological air monitoring study performed in Marseilles city to highlight the situation in abroad. Number of the countries which monitor microbiological parameters in air are getting increased.

Environmental applications like wastewater, sewege treatment, waste landfill, composting etc. were investigated for bioaerosols which emitting from these operations. There are several studies about this issue, under this title some of them are summarized to indicate the extent of similar studies;

- Changes at an activated sludge sewage treatment plant alter the numbers of airborne aerobic microorganisms, Fernando, N.L. and Fedorak, P.M., 2005

  Nadeesha L. Fernando and Philip M. Fedorak performed bioaerosol monitoring study in August 2005 at the Gold Bar Wastewater Treatment Plant in Edmonton to show the differentiation in bioaerosol levels after many changes had been implemented to the plant since 1976. The objective of this study was to repeat the survey that was done in 1976 to determine whether the changes at the Gold Bar plant reduced the numbers of airborne microorganisms.

  As a result of first study; Fedorak and Westlake (1980) reported that the activated sludge tanks typically produced the largest numbers of airborne microorganisms, and that the highest counts among these tanks were observed at night, when the rate of aeration was highest. Similarly, at other

outdoor plant locations where aeration is used (such as in the influent to the primary and final settling tanks, and in the grit tanks), the numbers of airborne microbes were elevated. Surprisingly, some very high numbers of airborne microorganisms were observed at indoor locations, near sewage sampling sinks (Fedorak and Westlake, 1980).

By the year 2004, the plant has expanded in size and capacity, and new buildings had been taken on site. Many of the primary tanks were covered to control odors, and the secondary had fine bubble aeration. Although these changes were not specifically made to reduce the numbers of airborne microorganisms, it was hypothesized that many of the changes would reduce the production of microbial aerosols at the plant.

In addition to the first study, some new outdoor and indoor locations were sampled to assess the numbers of airborne microorganisms at these locations. As a result Nadeesha L. Fernando and Philip M. Fedorak made comparison with the study results of Fedorak and Westlake which performed in 1976.

As a result of this study Nadeesha L. Fernando and Philip M. Fedorak stated that the 2004 air sampling survey showed that, in most cases, these changes have also drastically reduced the bioaerosols generated at various locations in the plant. Covering the grit tanks and influent portions of the primary settling tanks, where coarse bubble aeration is used, has markedly reduced the numbers of airborne microorganisms. The most significant reduction in aerosol generation has been in the secondary where fine bubble aeration has replaced coarse bubble aeration. Although the number of bioreactors in the secondary has doubled, the average number of airborne microorganisms (over a 24 h sampling period) in this section of the plant is about 1% of what it was in 1976. Nadeesha L. Fernando and Philip M. Fedorak concluded that the highest numbers of airborne microorganisms in enclosed locations are found in the building containing the dissolved air floatation tanks and in the tent housing the membrane ultrafiltration unit. The aeration used in these two processes generates bioaerosols that are trapped in the enclosures. Neither the 1976 nor the 2004 survey studied the types of airborne microorganisms at the Gold Bar plant. Only the numbers of microorganisms that formed colonies were determined during this study. These numbers are simple indicators of

the microbial loads in the air, and they are useful to compare changes in the densities of airborne microorganisms and to detect locations that have high numbers. Obviously, lower microbial densities indicate that workers and people near the plant will be exposed to fewer airborne microorganisms, thereby reducing the potential for exposure to pathogens.

- Assessing Airborne Biological Hazard From Urban Wastewater Treatment, Carducci, A., Tozzi, M.E., Rubulotta, E., Casini, B., Cantiani, L., Rovini, E., Muscillo, M. And Pacini, R., 1999

  Carducci et al. had been performed study on the production of microbial aerosols by urban sewage treatment plants regarding the operation's wide hygienic implications. They reported that the reason of their study is exposure to such aerosols may in fact represent a health hazard for plant workers and nearby residents alike.

  This study performed at several plants in the City of Leghorn (Livorno, Italy). Monthly aerosol samples were collected with an agar impact sampler from January to November 1996, from different sites at an activated sludge plant, an anaerobic sludge plant and a wastewater washing station. The total bacterial and coliform counts were determined, and pathogenic enteric bacteria and viruses were determined. These same parameters were also measured in wastewater and sludge samples obtained at the same sites. The results revealed that high-grade airborne contamination existed at several of the studied sites. The biological parameters measured had no evident correlation with meteorological factors such as temperature, relative humidity or wind characteristics. The monitoring performed allowed for a determination of the areas of greatest potential risk for plant workers, and the preventive measures most suitable to guaranteeing their safety. Microbial air contamination was monitored in order to obtain measures of both bacteriological (total bacteria count, total coliform and enteric pathogen counts), and virological (cytopathic viruses) parameters for the various components (collection, treatment and disposal) of the sewage treatment system serving the city of Leghorn (Italy), with particular attention to those areas most frequented by plant personnel.

Carducci et al. concluded that the highest levels of contamination, in both quantitative and qualitative terms, were found at the washing station. Moreover, areas in the vicinity of moving mechanical equipment (primary and secondary screen and screw conveyors) or machinery performing wastewater aeration (grit chamber) yielded mid-to-high concentrations of bacteria, while the areas surrounding the aeration tanks did not appear to be highly contaminated.

- The seasonal distribution of bioaerosols in municipal landfill sites: a three year study, Huang, C.Y., Lee, C.C., Li, F.C., Ma, Y.P., Su, H.J.J., 2002

  Landfill is the most common way to dispose waste in many countries, and most landfill sites after closure are often considered for public recreation purposes. It is important that the pollutant levels of closed landfill areas are free of adverse health concerns. Huang, C.Y., et al. (2002) stated that the objective of their study was to document the bioaerosol levels in a closed landfill site while the temporal, seasonal, and meteorological effects were also taken into accounts.

  Study site was at one sanitary landfill, taking mostly municipal wastes, in southern Taiwan. Airborne bacteria and fungi were collected on tryptic soy agar (Difco) and malt extract agar (Difco) by a Burkard impactor. Air samples were collected sequentially in winter, spring, summer and fall in 1998, winter, spring, summer in 1999, as well as summer and fall in 2000. In addition, sampling was conducted in the morning, at noon, in the evening and the following morning during each field assessment. Levels of airborne bacteria and fungi were all far above 103 CFUm^3. The concentrations of culturable bacteria and fungi were higher in winter than in other seasons. The difference of bioaerosol level and fungal percentages between the undergoing-closure and closed areas was obvious, and the concentrations were higher in closed area.

  Huang, C.Y., et al. (2002) concluded that the landfill site after closure, therefore, may not be appropriate for the immediate use by the public, at least in this part of the world. How long it will take for the landfill site to become

stable in terms of releasing airborne microbes could not be determined in this study.

- Atmospheric pollution by airborne microorganisms in the city of Marseilles, Giorgio, C., Krempff, A., Guiraud, H., Binder, P., Tiret, C. and Dumenil, G., 1996

  Outdoor airborne microflora was investigated by the Giorgioa, C., et al. in urban and natural areas, the city of Marseilles and the natural reserve of Porquerolles Island, respectively in 1999. In Marseilles, concentrations of airborne viable microorganisms averaged 791 ± 598 bacteria/m³ (with a geometric mean of 536 ± 103 bacteria/m³) and 92 ± 92 fungi/m³ (with a geometric mean of 63 ± 15 fungi/m³). In Porquerolles Island, concentrations of airborne microorganisms reached 42 ± 70 bacteria/m³ (with a geometric mean of 26 ± 7 bacteria/m³) and 46 + 55 fungi/m³ (with a geometric mean of 33 ± 8 fungi/m³). Airborne microflora, which increased a log-normal distribution in Marseilles, was shown to have a large variability. Airborne bacteria increased with temperature and wind velocity whereas airborne fungi increased with temperature and varied with wind direction in urban and natural areas. Partial identification of bacteria in Marseilles and Porquerolles Island showed that geographical location had qualitative as well as quantitative influence on airborne microflora, this was illustrated by an increase of global airborne microorganisms, and more particularly Gram negative bacteria, in the urban area.

- Sorting and recycling of domestic waste. Review of occupational health problems and their possible causes, Poulsen, O.M., Breum, N.O., Ebbehoj, N., Hansen, A.M., Ivens, U.I., Lelieveld, D., Malmros, P., Matthiasen, L., Nielsen, B.H., Nielsen, E.M., 1995

  Several studies have reinforced the hypothesis that exposure to airborne microorganisms and the toxic products thereof are important factors causing a multitude of health problems among workers at waste sorting and recycling plants. Workers at transfer stations, landfills and incineration plants may experience an increased risk of pulmonary disorders and gastrointestinal problems. Poulsen, O.M., et al. Stated that high concentrations of total

airborne dust, bacteria, fecal coliform bacteria and fungal spores have been reported. The concentrations are considered to be sufficiently high to cause adverse health effects.

- Sick Hospital Syndrome, Ozyaral, O.

  Özyaral, O. were studied about sick hospital syndrome, analysed the reasons.

  Özyaral, O. stated that molds require wide temperature interval to remain viable, in the same time they require 75% relative humidity. Consequently, *Stachybotry* posses high risk for human health and requires 25°C and 93% relative humidity. If, temperature and nutrients in the surrounding environment are increased, molds could require less humidity. Dirty wall paints, paper covered surfaces etc. provides good environment for mold growth, even there is low humidity value.

  Most probably seen mold types are; *Penicillium* (%96), *Cladosporium* (%89), *Ulocladium* (%62), *Geomyces pannorum* (%57) and *Sistronema brinkmannii* (%51).

  Özyaral, O. concluded that there is a strong relationship between mold growth and sick building syndrome.

3. MATERIALS AND METHODS

3.1.Plan of the Study

Measurements of the concentrations of airborne material near dominant sources ie. wastewater treatment plants, composting facilities etc. are reviewed for both area sources, and for point sources such as sewage and wastewater treatment work. Investigation into the types and numbers of airborne microorganisms was carried out in three varying types of municipal wastewater treatment plants to establish future reference standards and to determine if they can affect surrounding areas, and to possibly help assessing what degree they may affect human health.

This project was carried out in Istanbul which is located in the western province of Turkey. It has a population over 10.000.000.

Total Bacteria, Total Coliform, Fecal Coliform and Total Fungi are monitored as biological parameters. Additionally, wind velocity, wind direction, temperature, humidity, weather situation, sampling height and distance are monitored as critical environmental parameters.

Any interferences had been applied to that treatment plants during the sampling. Samples had been taken during normal operational conditions. There were no different human or animal activities in the residences/plants during the sampling period. To minimize temporal variations, at some locations indoor and outdoor air was sampled at the same time.

Eight set of measurements, 368 samples were taken over six months during winter and spring 2006.

Table 3.1 : Sampling Strategy

Set Number	Aim	Sample
1	determination of sampling volume	20 Samples
2-4	determination of airborne microorganism	213 Samples
5-8	focusing on the units which emits more bioaerosols	135 Samples

Samples were collected using a microbial mechanical air sampler for the enumeration of bacteria, fungi and coliform concentrations as colony forming units (CFU). Merck Eco100 microbiological air sampler had been used on 3 occasions over 6 months to monitor winter variation.

Sampling points were selected to reflect the airborne contamination. Results were compared by taking samples from reference points around Istanbul city and different points on and around that treatment plants. In every treatment plant, ~10 sampling points were selected. These sampling points have similar characteristics to provide comparison chance.

There are several difficulties encountered in sampling biological aerosols and the evaluation of data obtained and identifying related health effects encountered. Previous studies showed that the bioaerosol occurence can depend on several factors; treatment plant capacity, treatment process type, hygienic measures, mechanical movement etc.

The concentration of airborne material remote from sources is considered along with the effects of wind, humidity and temperature. Consequently; wind velocity, direction, temperature and humidity also measured. Wind can dilute the airborne microorganisms emitted from point resource which monitored or can transport some examples of materials from long distance sources other than monitored source. The vertical concentration differentiation have not been studied. The short-term variation of bioaerosol concentrations are also considered. Consequently, some critical environmental factors had been monitored to analyse differences between sample results.

Geographical and regional monitoring of indoor microorganisms has not been studied locally.

Wind speed data and general weather conditions were obtained from a local meteorological station.

Wind speed data and general weather conditions were measured. Temperature and relative humidity were recorded for every point during the sampling campaigns.

The following protocols were applied to monitor, airborne microorganism concentrations and critical environmental factors in the wastewater treatment plants and their surrounding environment.

3.2.Residence Selection

Aim of this study is to monitor the biological airborne microorganisms that outlined before. In the literature it was emphasized that treatment activities such as wastewater, sewage treatment, waste landfilling, composting etc. have potential to emit large number of microbial airborne pollutants.

Istanbul is the biggest city of Turkey regarding population. There are several municipal wastewater treatment plants; they vary in treatment process type, wastewater characteristic and capacity. Some of these plants are matter of concern because they are located very close to public residences.

Initially, all of the environmental treatment plants around Istanbul had been assessed and Tuzla Biological Municipal Wastewater Treatment Plant, Pasakoy Advanced Biological Municipal Wastewater Treatment Plant and Atakoy Biological Municipal Wastewater Treatment Plant had been choosen according the issues mentioned above.

3.3.Description of the Sites and Sampling Points

Measurements of the concentrations of airborne material near these dominant sources are reviewed for both area sources, and for point sources.

Outdoor and some indoor air samples were collected and characterized. Sampling point selection was based on similarity in extent of main treatment units.

Sampling points were selected to reflect the airborne contamination. In every treatment plant, minimum 10 sampling points were selected. These sampling points have similar characteristics for giving comparison chance.

There were no differentiation between day and night regarding treatment operations.

Wind ventilation was the main thing which ventilates these areas when samples are taken.

3.3.1. Tuzla Biological Wastewater Treatment Plant

Tuzla municipal wastewater treatment plant has been started to operate from 1998. Aim is to preventing Marmara Sea from municipal pollutants. Pollutants are coming from Gebze, Darica, Cayirova, Tuzla, Pendik and Kartal residences. Collection channels have 4500 mm diameter.

Figure 3.1 : General View of Tuzla Municipal Wastewater Treatment Plant

Tuzla municipal wastewater treatment plant operates as conventional activated suldge process. Advanced biological treatment processes -biological phosphorus and nitrogen removal units- will be installed in the close future.

Today, Tuzla biological wwtp has a capacity of 450.000 m³/d (2.250.000 Person).

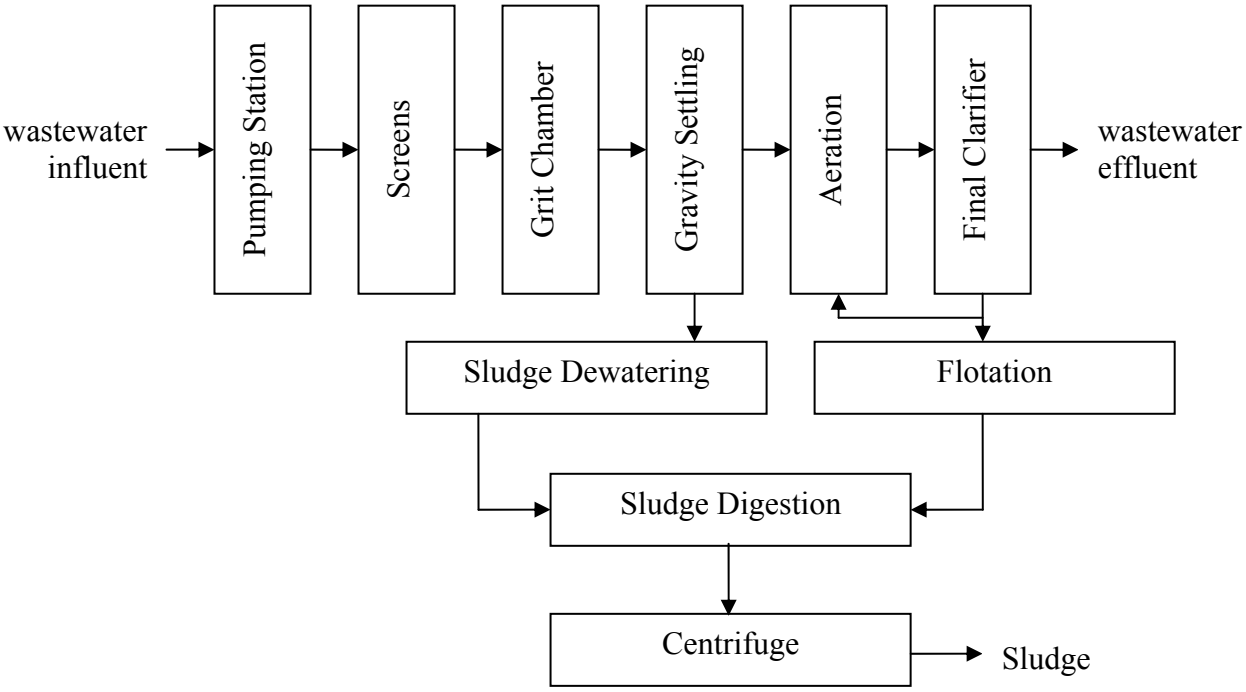


Figure 3.2 : Tuzla WWTP Process Flow Chart

Wastewater treatment plant consists of pretreatment units, biological treatment and sludge dewatering units. Treatment units are explained below in general;

Wastewater influents come from Pendik and Tuzla pass through mechanically cleaned bar screens (course and fine) as a first step. Bar racks are used to protect pumps, valves, pipelines, and other appurtenances from damage or clogging by rags and large objects. Screens composed 120 and 18 mm parallel bars and have mechanical cleaning system. Bar screens are working with automatically cleaning system and wastes are transmitted into a container through a conveyor. Wastes collected in the container are transferred to landfill area.

Wastewater passing from bar screens enters into aerated grit chambers. Grit chamber retention time is 4 min. Sand which settled in the bottom is conveyed to sand seperation funnel and sand are conveyed wastewater container with screw conveyor.

Also grease acumulated in the surface, are scraped with surface scraper on the bridge then they are taken to a collection tank.

Effluent from aerated grit chambers goes to first primary settling tanks. There are 4 tanks and tank volumes are 2682 m^3. Retention time is 2 hours. Settled materials are scraped with bottom scraper then they are taken into sludge thickening unit for ~26 hours. Then sediments pumped into the sludge digestion tanks. There are 2 sludge digestion tanks of 530 m^3.

Wastewater effluent from primary settling that don't include settelable materials can be treat biologically in the aeration tanks. Volume of each aeration tank is 6000 m^3. There are 4 tanks. In the aeration tanks, mainly organic carbon has been removed and the air is obtained by blowers.. Air from the blower is distributed efficiently by diffusers.

Activated sludge comes to the secondary clarifiers after the biological reactor. The treated water is collected by weirs and is send to discharge units. Primary and excess sludge are dewatered by sludge treatment units.

Sampling points are illustrated in the figure 3.3.

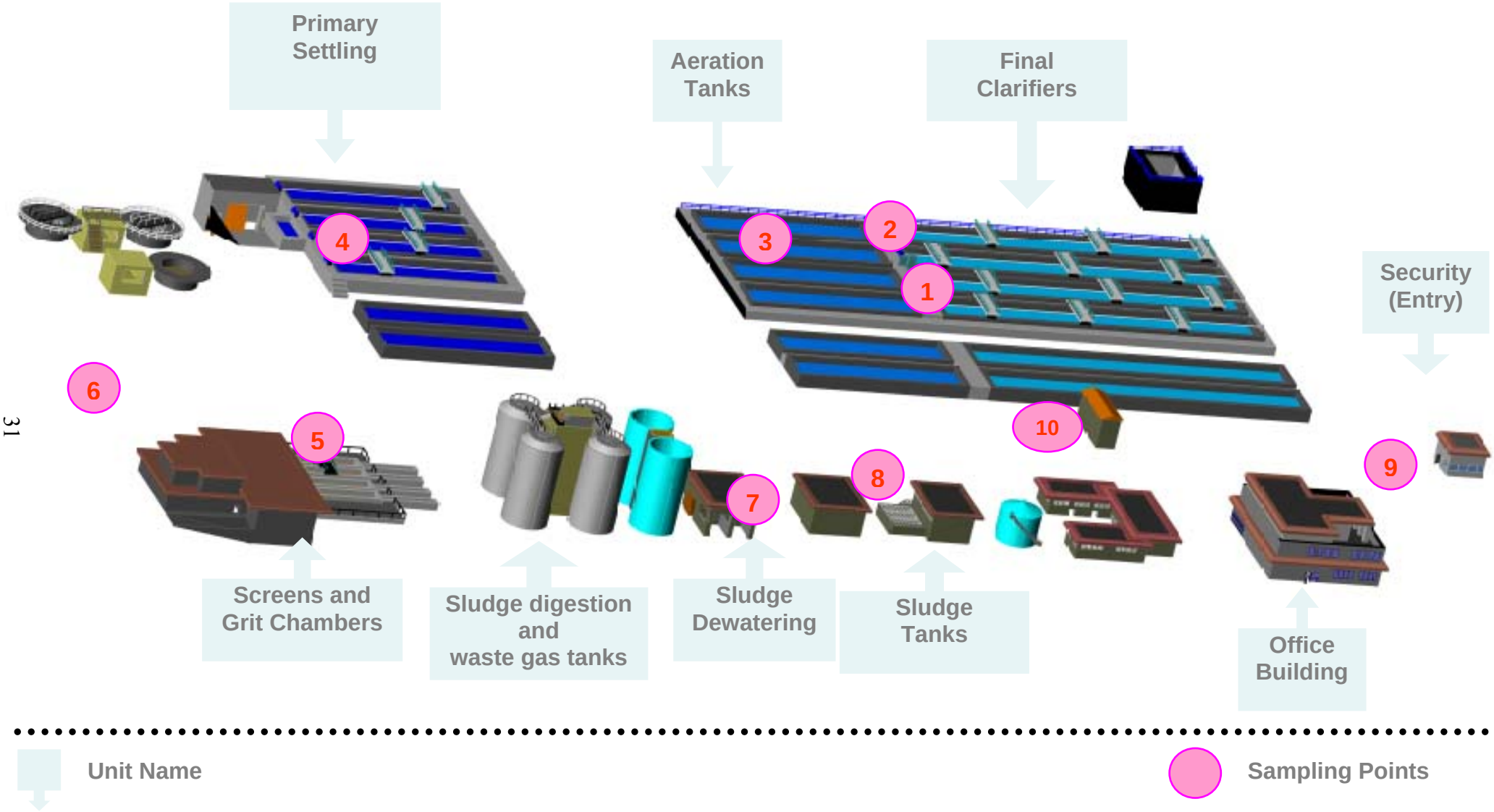


Figure 3.3 : Sampling Points in Tuzla Biological MWTP

3.3.2. Paşaköy Biological Wastewater Treatment Plant

Paşaköy WWTP was built in 2000 and design capacity of plant is 250.000 pe and 100.000 m³/d of domestic wastewater (500 kg P/d load) (table III.1). The plant was designed for removal of organic matter (COD), nitrogen (N) and phosphorus (P). Treatment plant based on advanced biological treatment process technology and designed as A2/O process; anaerobic zone followed by anoxic then oxic zones aeration units. The main parts of treatment process and sludge treatment are consisting of;

- 3 anaerobic tanks
- 4 aeration tanks (operated as 50% anoxic)
- 4 final clarifiers
- Dissolved air flotation
- Sludge storage tank
- Sludge dewatering units

Following preliminary treatment wastewater goes into distribution unit (non-bulking selector) and then into the anaerobic tanks (Bio-P Unit)

The Bio-P Unit are constructed as three tanks. Three tanksa re operated in series. The activated sludge is kept in suspension by 2 slow going propeller stirrers in each tank. The stirrers are mounted on a fixed walkway across the tanks.

The COD and N removal accomplised in a biological system; the process tanksa re constructed as two paralel activated sludge units each with 4 channels in series. Channel 1 is always anoxic and other 3 channels are equipped with diffusers for aeration. Under normal conditioms channel 1 is operated without aeration (anoxic), channel 2 without aeration in summer time and aerated in winter time, channel 3 and 4 are aerated.

Each process unit is constructed and equipped so that hakf of the unit can be taken out of operation. In this situation both remaining channels will be aerated in order to maintain nitrification. Air is blown into channels through ceramic diffusers. There are 2+1 blowers each has 11000 Nm³/h capacity (250 kW).

The activated sludge is kept in suspension by 4 slow going propeller stirrers (banana blades) in each channel. The stirrers are mounted in pairs on two fixed walkways across the tanks. The mixers are operated continiously. Recirculation of wastewater from channel 4 to channel 1 is done by 4 submersible pumps in each process unit. The recirculation pumps are operated continiously.

The activated sludge leaves nitrification tank splitting into four final clarifiers. After settling, the purified wastewater is dischared into nearby recepient. A large fraction of the settled activated sludge is returned to the non-bulking selector and Bio-P tanks to maintain desired biomass concentration. Excess sludge is wasted from fourth aeration tank (nitrification tank) flows into dissolved air flotation unit. The sludge wasting rate results in a total sludge retention time in the system of approximately 15-25 days.

The concentrated sludge from the DAF unit gravitates to a sludge storage tank. The tank is equipped with slow moving mixers to keep the sludge homogenised and bottom air diffusers to keep it aerobic, so that phosphorus releases does not take place.

Figure 3.4 : General View of Tuzla Municipal Wastewater Treatment Plant

Sampling points are illustrated in the figure 3.5.

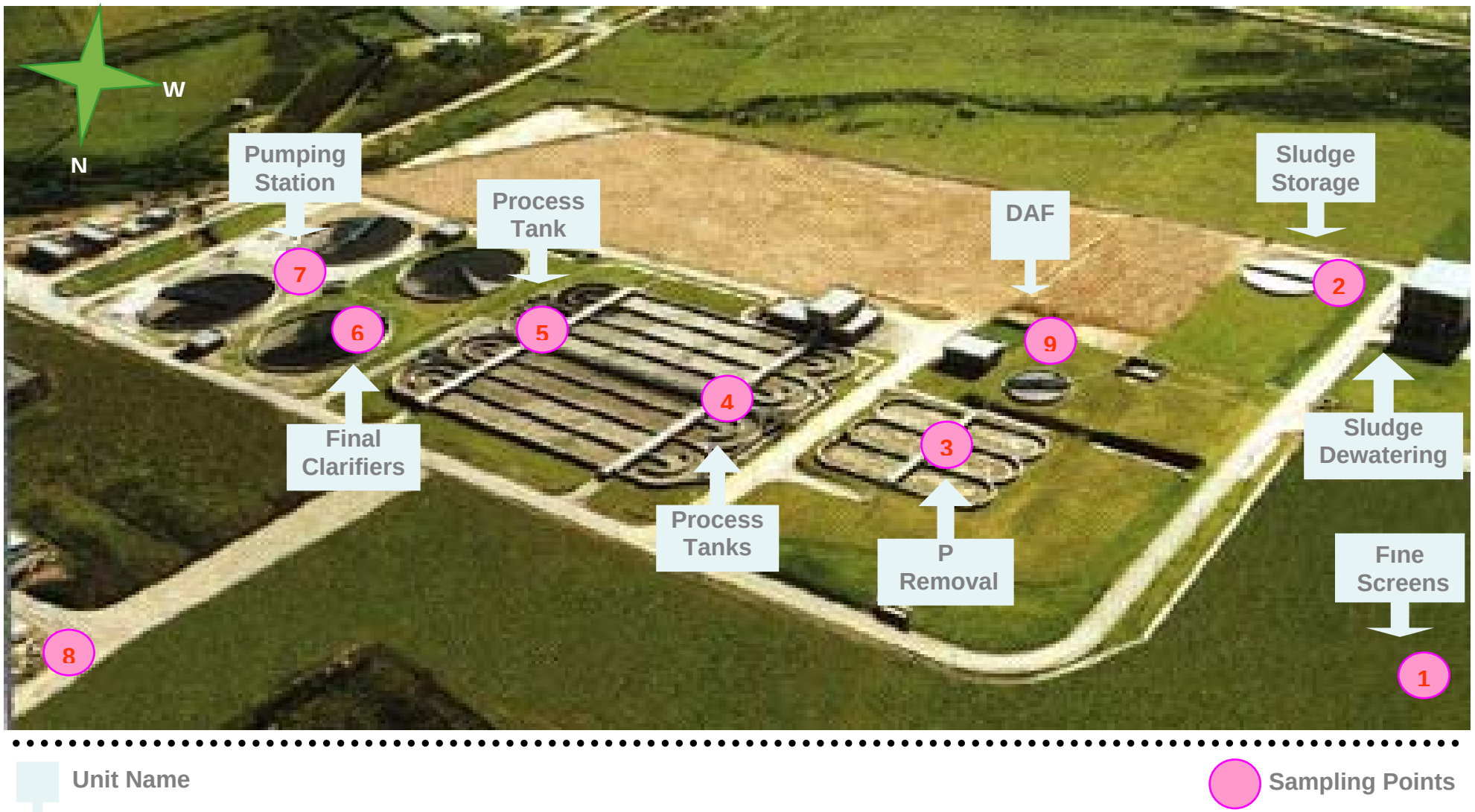


Figure 3.5 : Sampling Points in Pasakoy Advanced Biological MWTP

3.4.Measurement of Airborne Microorganisms

The reason for measuring bioaerosols in the air is principally to assess health hazards or risks by; determining both qualitatively and quantitatively what biological material is present; and monitoring the effectiveness of control.

The principles of sampling bioaerosols, may be common to all of the methods, but sampling and assay methods and materials will need to be chosen according to the biological material being studied and the environment in which it is found.

Special care was taken not to effect the normal operations and not to disturb the residences' interiors; this practice was meant to minimize particle reaerosolization and provide for sampling normalization among the residences sampled.

3.4.1. Biological Parameter and Culture Medium Selection

Bacteria and fungi are selected because in many atmospheric environments, airborne bacteria, fungi and their fragments may fall into a respirable size range that can penetrate deep into human lungs (< 10 _m) (Gorny et al., 2002)

The coliform group of organisms had been assessed because they are suitable as indicators. They are common inhabitants of the intestinal tract, both of humans and warm-blooded animals. Many of the pathogens found in warm-blooded animals also infect humans, as indicator of both human and animal pollution is desirable (Madigan, M.T., Martinko, J.M., Parker, J., 1997)

One of the basic characteristics of a microorganism is its nutritional requirements. A dehydrated culture medium is described as a substance or a group of substances that satisfies those nutritional requirements. With many simple and complex formulations of dehydrated culture media available on the market.

Culture media are formulated to create appropriate environments for specific microorganisms.

Following agars are choosed to monitor Total Bacteria, Total Fungi, Total Coliform and Fecal Coliform.

3.4.1.1.Plate Count Agar

This medium does not contain any inhibitors or indicators; it is mainly used to determine the total microbial content.

Figure 3.6 : Plate Count Agar

Typical Composition (ingredients per liter)

Peptone from casein	5.0 g
Yeast extract	2.5 g
D(+)glucose	1.0 g
Agar-agar	14.0 g

Method of Preparation (Ref : Merck, Product Label)

- Suspend 22.5 g in 1 liter of demineralised water by heating in a boiling water bath or in a current of steam, autoclave (15 min at 121°C). If desired, add 1.0 g skim milk powder/liter prior to sterilization.
- pH must be adjusted 7.0 ± 0.2 at 25°C.
- The plates are clear and yellowish.

3.4.1.2.Endo Agar

Endo Agar is selective culture medium and it is used for the detection and isolation of *E. coli* and coliform bacteria.

Figure 3.7 : Endo Agar

Mode of Action (Ref : Merck, Product Technical Data Sheet)

Sodium sulfite and fuchsin inhibit the growth of gram-positive bacteria. E. Coli and coliform bacteria metabolize lactose with the production of aldehyde and acid. The aldehyde liberates fuchsin from the fuchsin-sulfite compound, the fuchsin then colors the colonies red. In the case of E. coli, this reaction is so intense that the fuchsin

crystallizes out giving the colonies a permanent greenish metallic sheen (fuchsin sheen). Lactose-negative and wealkly lactose-positive E. coli do not show any fuchsin sheen.

Typical Composition (ingredients per liter)

Peptones	10.0 g
Di-potassium hydrogen phosphate	2.5 g
Lactose	10.0 g
Sodium sulfite, anhydrous	3.3 g
Pararosanilin (fuchsin)	0.3 g
Agar-agar	12.5 g

Method of Preparation (Ref : Merck, Product Label)

- Suspend 39 g in 1 liter of purified water. Autoclave (15 min at 121°C). Pour plates. The plates are clear and pale pink. If the culture medium is somewhat too red after it has solidified, the red coloration can be removed by adding a few drops (max. 1 ml/liter) of a freshly prepared 10 % sodium sulfite solution and then boiling.
- pH must be adjusted 7.4 ± 0.2 at 25°C.

3.4.1.3.Saboroud

This culture media is used for the detection of Yeasts and Molds

Method of Preparation (Ref : Merck, Product Label)

- Suspend 47 g in 1 liter of demineralised water by heating in a boiling water bath or in a current of steam; autoclave (15 min at 121 °C). Do not overheat.
- pH must be adjusted 5.6 ± 0.2 at 25 °C.
- The plates are clear and yellowish-brown.

Experimental Procedure and Evaluation

- The plates are inoculated with sample material according to the instructions.

- The fungi colonies which have grown are judged macro and microscopically. Incubation for up to 7 days at 28 °C aerobically.

Figure 3.8 : Saboroud

3.4.1.4.Violet Red

Selective agar is used for the isolation and enumeration of all *Enterobacteriaceae* species.

Typical Composition (ingredients per liter)

Peptone form meat	7.0 g
Yeast extract	3.0 g
Sodium chloride	5.0 g
D(+)glucose	10.0 g
Bile salt mixture	1.5 g
Neutral red	0.03 g
Crystal violet	0.002 g
Agar-agar	13.0 g

Mode of Action (Ref : Acumedia, Product Technical Data Sheet)

Crystal violet and bile salts inhibit the accompanying bacterial flora. Degradation of glucose is accompanied by production of acid, which is indicated by a color change to red and by zones of precipitated bile acids surrounding the colonies. All Enterobacteriaceae are detected as they all degrade glucose to acid. The culture medium is not, however, absolutely specific for these organisms as some other accompanying bacteria (e.g. Aeromonas) also show these reactions.

Method for Preparation (Ref : Acumedia, Product Label)

- Suspend 39.5 g in 1 liter of purified water and heat to boiling with frequent stirring until completely dissolved. Afterwards do not boil more than 2 minutes.

  This agar should not been autoclaved and overheat.
- pH must be adjusted 7.3 ± 0.2 at 25°C.
- The prepared medium is clear and dark red.
- Incubation: for 24 hours at 35°C aerobically.

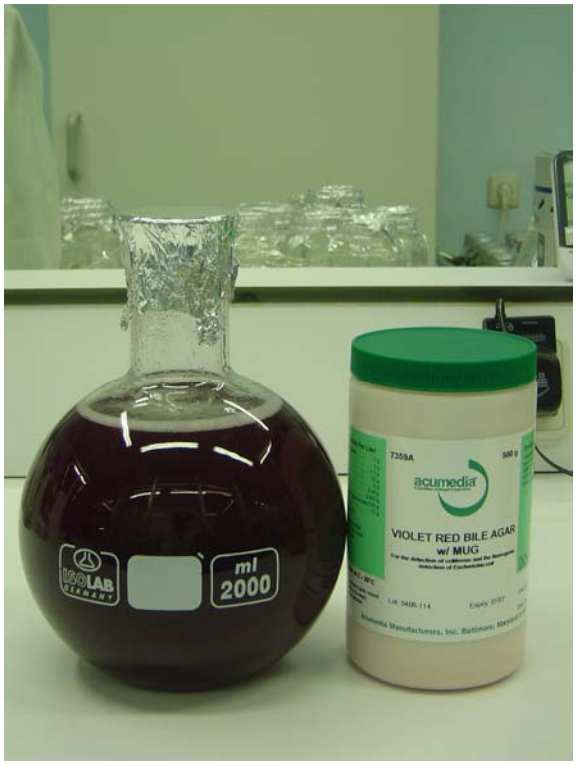


Figure 3.9 : Violet Red

3.4.2. General Procedure for Preparation and Storage of Culture Media

3.4.2.1.Reconstitution of Dehydrated Media:

The complete procedure for dehydrated media is printed on the labels of each bottle which explained for selected agars under the title 3.4.1, 3.4.2, 3.4.3 and 3.4.4.

The following points are the general procedures for reconstitution of dehydrated media.

- Always use freshly prepared distilled or deionised water free from toxic metals.
- Check the pH of the water. pH must between the range given in product label.
- Rinse all the glassware with the checked distilled or deionised water and make sure than the vessels are free from the toxic chemicals.
- In order to allow good rinsing the volume of the glass ware should be twice the volume of the final culture medium. Follow the instructions given on the label of the product.
- Open the culture medium away from the moisture. Avoid inhaling the powder and prolonged skin contact. Weight the powder without forming a cloud quickly and close the bottle.
- Pour half the required volume of distilled water in the vessel, than the weighted quantity of medium and agitate briskly for a few minutes. Pour the rest of the distelled water down the sides of the vessel to wash any adherent medium.
- The culture medium containing agar shall be heated to dissolve the agar before autoclaving. Take care not to burn the mixture.
- For sterilisation of the prepared culture media, put the culture media into the autoclave with the recommended parameters.

3.4.2.2.Dispensing Media

Medium should be cooled in a water bath to 50 - 55°C prior to dispensing.

Gently swirl medium before and during dispensing to ensure that it is evenly mixed. Dispense quickly.

Pouring process should be done under the Laminar Air Flow Cabinet which has proper air circulation to maintain sterile working environment, product and occupational safety.

Immediately recap or recover petri dishes to reduce the chance of contamination. Petri dish covers should be slightly ajar for 1 – 2 hours to reduce moisture build-up on lids.

Figure 3.10 : Pouring the Agar under the LAF Cabinet

3.4.2.3.Storage of Prepared Petri Dishes

Dehydrated culture media are hygroscopic and sensitive to heat, light, and moisture. Store the prepared media away from light. Store the agar plates at 2-8°C in sealed containers and broth culture media at room temperature. Record the date of preparation on a cultures.

The recommended expiration date of prepared culture media varies greatly. Screw-capped tubes can be stored for 6 months or longer at low to ambient temperatures.

Plated media may be stored inverted in a plastic bag or other container in a refrigerator for 1 – 2 weeks or longer.

3.4.3. Quality Controls On Culture Media

3.4.3.1.Label Control

Check for the lot number, name and the expiry date of the culture medium.

3.4.3.2.Test to be Performed on Prepared Culture Media for Quality Control

The pH Analysis, Sterility Tests, Growth performance test applied to every lot of culture media.

- pH Analysis

Check the pH of the prepared medium at 25°C. The found pH should not be exceed the ranges written on the label.

- Sterility Test

For a lot of 100 or less units a 3-5% sample should be tested. For a larger lot, test 10 random plates or tubes. Each media shall be incubated at proper temperature for determined period.

If there is growth on Petri plates or tubes incubated, examine the area where culture prepared in respect of possible biocontamination sources. If there is still growth, petri plates or tube shall not be used.

- Growth Performance Test

Inoculate less than 100 CFU's of the type of microorganisms in conformity with the manufacture recommendations and observe the growth in the plates incubated at the temperature and duration recommended by the supplier. Observe for growth. For every new kind of culture media prepared, test for 5 tubes or plates. Use incubation time and temperature of microorganisms which were written on current USP also consider manufacturer recomendation.

If there is no growth on Petri Plates or tubes inoculated by a determined microorganism, test should be repeated after examining the method of preparing media and the microorganism inoculated. If there is still no growth, petri plates or tube shall not be used.

3.4.4. Using The Prepared Culture Media

Examine the prepared culture media according to contamination, bubble formation, hemolysis formation, color changes, etc prior to usage.

The discarding of inoculated culture medium should be accepted as biohazardous waste and must be autoclaved before discarding.

3.5.Microbiological Air Quality Sampling Protocol

Impactors were placed 1.5m above the floor. Agar plates loaded into the impactor were prepared according to manufacturer's recommendations, and media plates were incubated and counted as previously outlined.

3.5.1. Bioaerosol Collection

A number of bioaerosol sampling methods are available. The conditions of sampling and analysis considered prior to the choice of the sampler and Merk MAS-100 Bological Air Sampling Device had been choosen to perform bioaerosol collection study because it is collect bioaerosols directly onto agar media. Wastewater treatment plants located relativeley far distance from the laboratory and samples had to be taken directly onto the agar. Impaction samplers are portable and provide mentioned requirement.

The grid of the MAS-100 sampler contains 400 holes, 0,7 mm in diameter which are regularly distributed over the grid surface.

Merck MAS-100® Microbial Air Monitoring Systems are based on the Anderson Principle, accepted and proven worldwide. Every unit uses standard 100mm Petri dishes which allows to incorporate them immediately into our protocols without having to change media.

MAS-100 Eco™ portable air sampler was designed specifically for use for sampling air. These compact devices are the preferred choice for those demanding the highest quality air-monitoring. It offers features that make them extremely accurate and reliable yet still easy to use and maintain.

Table 3.2 : Technical Specifications for Merck Eco100 Biological Air Sampler

Technical Specifications	
Height	26 cm
Diameter	11 cm
Weight	2.2 kg
Material	Anodized aluminum
Diameter of Sampling Head	10 cm
Nominal Airflow	100 liters / min ± 2.5%
Standard Sampling Volumes	50, 100, 250, 500, 1000
Freely Definable Sampling Volumes	1 to 2000 liters
Battery Pack	NiMH rechargeable battery, 10V
Motor	6V
Display	Alphanumeric liquid crystal display, 32 characters
Lifetime RTC Battery	RTC (Real Time Clock) battery; good for about 10 years
Driving Motor	PWM frequency for driving motor
Processor	Type 80C552
Airflow Regulation	Hot-wire anemometer, numerical control
CE Approval	EN 55022 Class B, EN 61000-4-2, ENV 50140, ENV 50204, EN 61000-4-4, ENV 50141
Power Unit/Battery Charger	110-240 Volt, 50-60 KHz

This lightweight unit, like all our systems, uses standard 100mm Petri dishes which means you can use the same media used in your lab. No revalidation is necessary.

The handle doubles as a stand to allow different angles for testing. Internal software is easily accessed and controlled using single touch "yes" or "no" responses and pre-programmed volumes assure reproducible results. The unit is pre-calibrated but re-calibration can be handled with the addition of DA-100® digital anemometer.

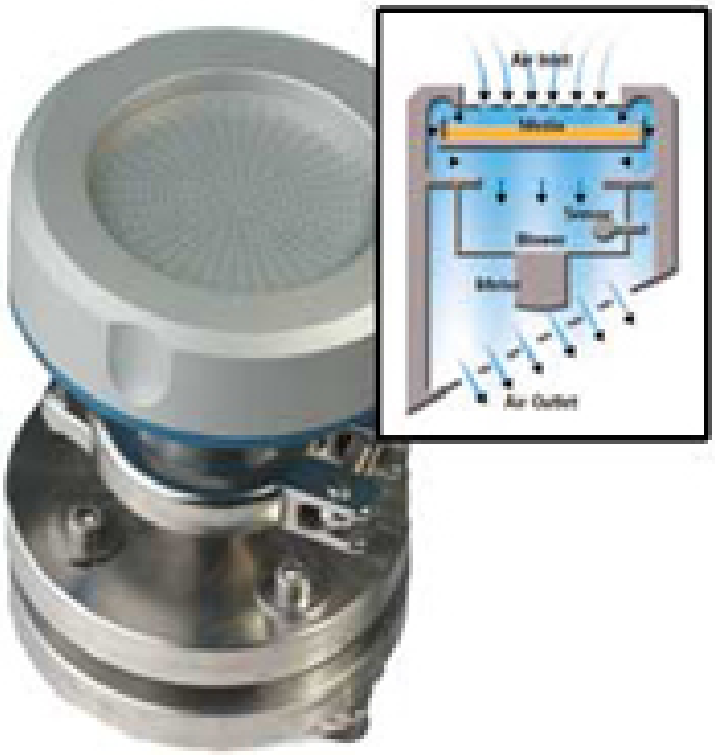


Figure 3.11 : MAS 100 Eco™ Process Scheme

3.5.2. Air Sampler : Instruction For Use

- Wear sterile gloves.
- Open the cap before using.
- Bind the petri plate to the equipment.
- Adjust the air volume and timer by using top buttons of the equipment.
- Keep sampler 1.5 m above from the ground.
- Open the on/off button(red button) and operate it.
- The equipment is stopped automatically when adjust time is finished. Close the equipment by using red button.
- Put petri dishes out of device.

NOTE : Before sampling, device cap was washed with deionized water and 70% ethanol and autoclaved for 15 min at 121°C. Device was disinfected with 70%

ethanol before every set. Immediately after collection, samplers were shipped to the laboratory.

Figure 3.12 : Example for Air Sampling

3.5.3. Wind Velocity Measurement

Wind velocity and direction measurement was performed with DA 4000 Digital Anemometer. This device operates continiously during 16 second and then gives the result in MPS as minimum and maximum value.

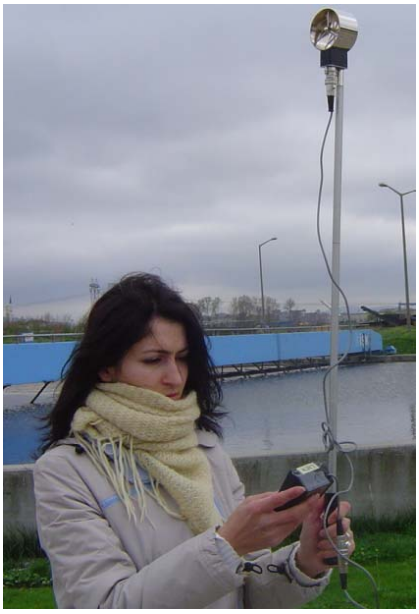


Figure 3.13 : Example for Wind Velocity Measurement

3.5.4. Colony Counting

Stuart Particle Counter was used to count colonies. This device has counter, lens, illumination and squared ground to maintain accurate counting.

Viable count procedure is used for counting the colonies. Procedure is described under the title 2.8.

Figure 3.14 : Picture of Particle Counter

4. RESULTS

Airborne microorganisms at various outdoor locations were sampled during this project. For some of the critical points indoor samples were taken. The results are summarized in Appendix 1 which shows the counts from this survey and the weather conditions, temperature and humidity during sampling campaign.

First discussion under the title 4.1 will focus mainly on the counts of different sampling volumes and the determination of appropriate sampling volume.

Second discussion will focus mainly on the counts of every biological treatment processes. Second discussion is under the title 4.2 and 4.3.

Title 4.3 will focus mainly on the comparison of the results from Tuzla and Paşaköy wastewater treatment plants for same treatment processes.

4.1. Sampling Volume Determination : Ataköy Biological Wastewater Treatment Plant Study

Initially, sampling volume determination study was performed in Ataköy Biological wastewater treatment plant.

Results of the samples are given in the figure 4.1 which were taken in 10, 50, 100, 200 and 1000 m^3/hr volumes.

Formed colonies has to be in the range of countable numbers. 10 and 50 m^3/hr volume results are considerably low. 200 and 1000 m^3/hr volume results are greater than countable ranges.

As a conclusion, 100 m^3/hr volume had been choosen as suitable volume to use during sampling campaign.

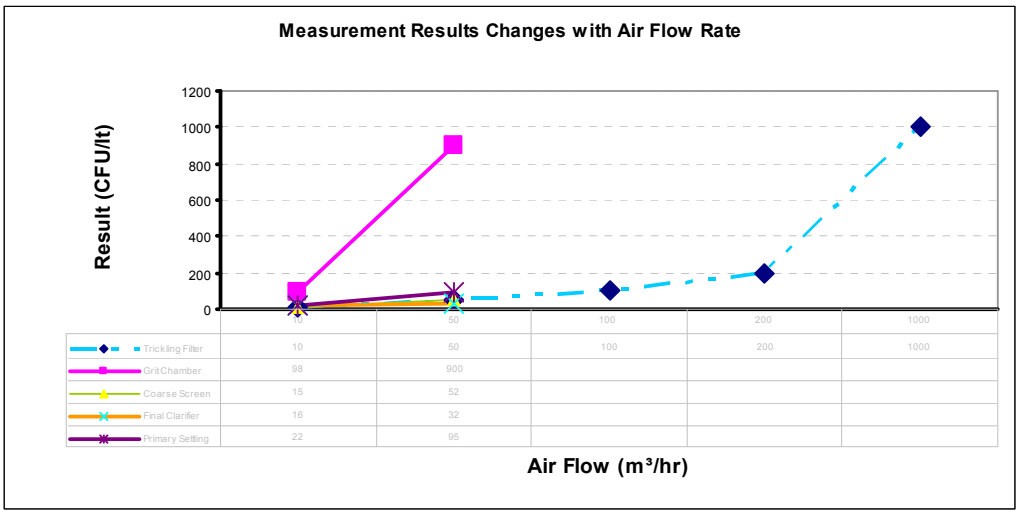
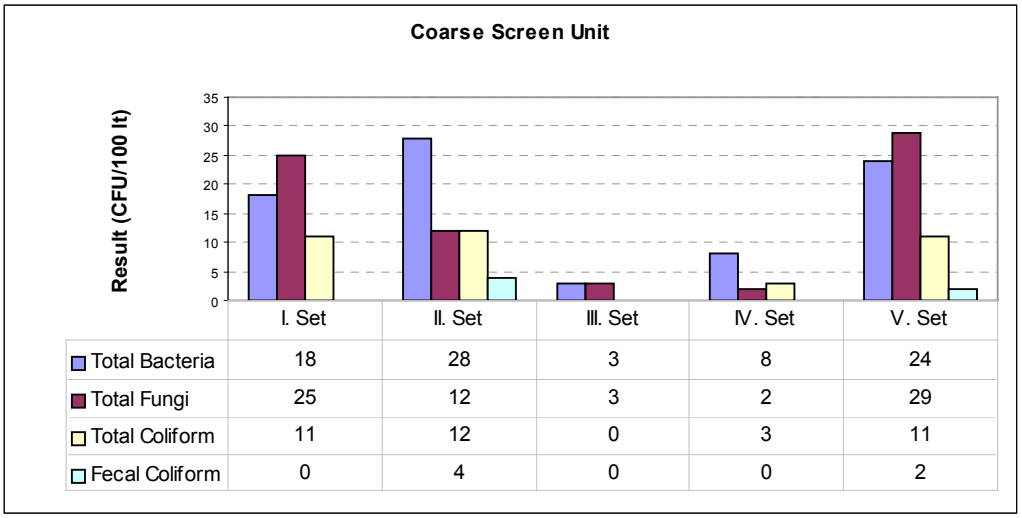


Figure 4.1 : Measurement Results Changes with Air Flow Rate

4.2.Airborne Microorganisms in the Tuzla Biological Wastewater Treatment Plant

Following graphics show the counts of Tuzla Biological Wastewater Treatment Plant survey.

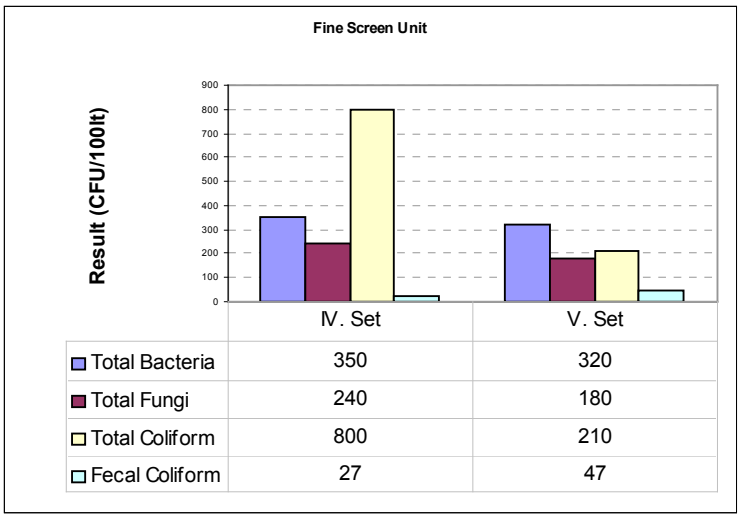


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	18	28	3	8	24
Total Fungi	25	12	3	2	29
Total Coliform	11	12	0	3	11
Fecal Coliform	0	4	0	0	2

Figure 4.2 : Bioaerosol Counts of Tuzla WWTP Coarse Screen Unit

The first unit operation encountered in wastewater treatment plants is screening. A screen is a device with openings, generally of uniform size, that is used to retain the solids found in wastewater.

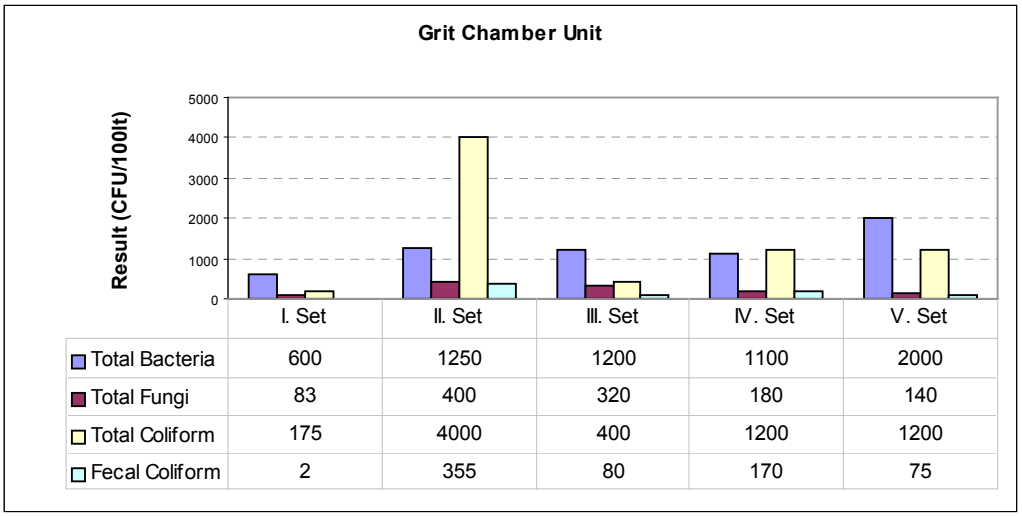
Results of coarse screen unit is relatively low when compared with other unit operations.



	IV. Set	V. Set
Total Bacteria	350	320
Total Fungi	240	180
Total Coliform	800	210
Fecal Coliform	27	47

Figure 4.3 : Bioaerosol Counts of Tuzla WWTP Fine Screen Unit

Fine screens have smaller openings than coarse screens. Because of that counts are higher than the coarse screen's counts.

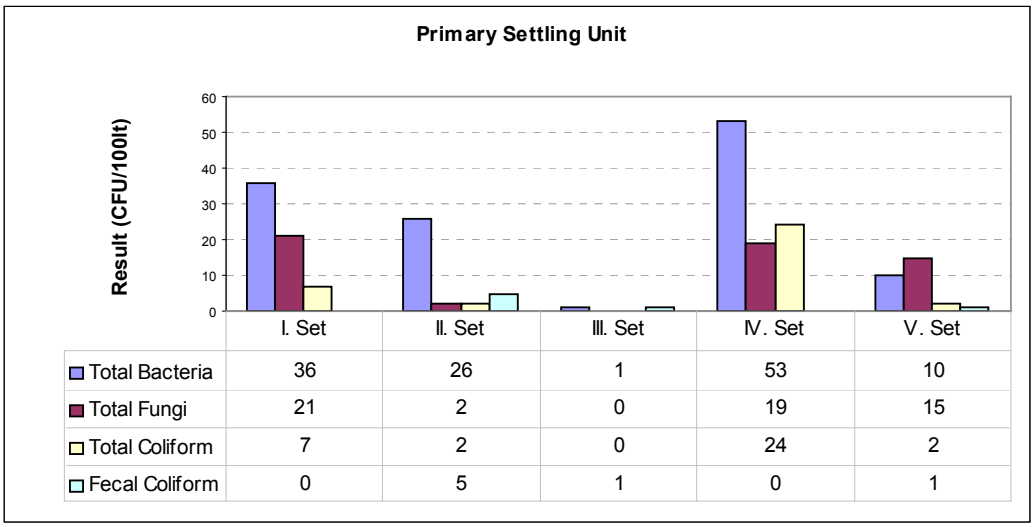


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	600	1250	1200	1100	2000
Total Fungi	83	400	320	180	140
Total Coliform	175	4000	400	1200	1200
Fecal Coliform	2	355	80	170	75

Figure 4.4 : Bioaerosol Counts of Tuzla WWTP Grit Chamber Unit

Grit chambers are provided to protect moving mechanical equipment from abrasion and accompanying abnormal wear; reduce formation of heavy deposits in pipelines, channels, and conduits; and reduce the frequency of digester cleaning caused by excessive accumulations of grit. Grit chambers are located after the screens.

Grit chamber unit is mechanical treatment step and this unit is mechanically aerated. Aeration triggers the bioaerosol emition. Counts of this unit process have highest result when compared with other unit operations.

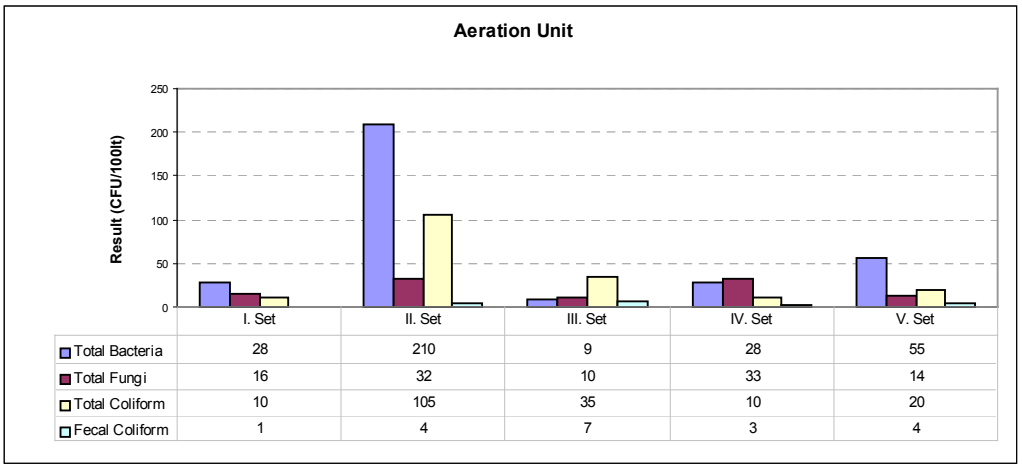


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	36	26	1	53	10
Total Fungi	21	2	0	19	15
Total Coliform	7	2	0	24	2
Fecal Coliform	0	5	1	0	1

Figure 4.5 : Bioaerosol Counts of Tuzla WWTP Primary Settling Unit

When a liquid containg solids in suspension is placed in a relatively quiescent state, those solids having higher specific gravity than the liquid will tend to settle, and those with a lower specific gravity will tend to rise. These principles are used for primary settling unit processes. The objective is to remove readliy settleable solids and floating material and thus reduce the suspended-solids content.

This step is also mechanical treatment process and have smaller counts than other unit processes.



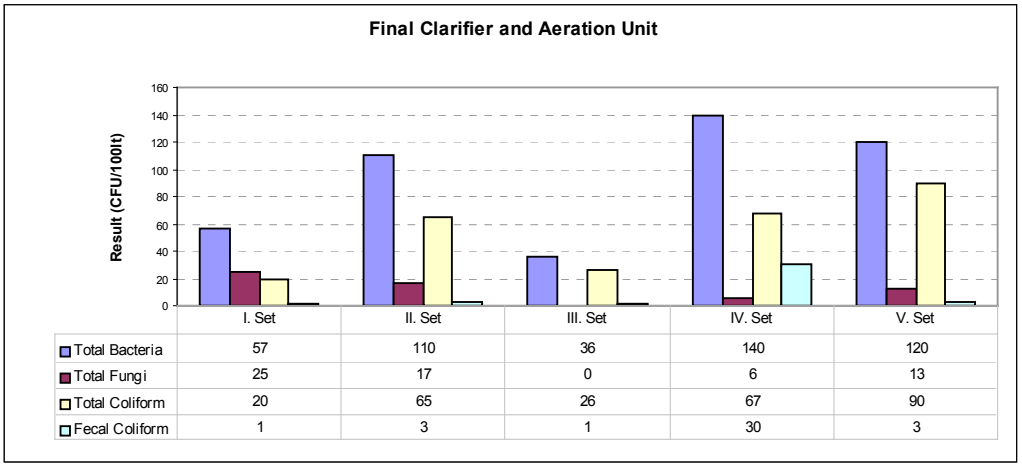
	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	28	210	9	28	55
Total Fungi	16	32	10	33	14
Total Coliform	10	105	35	10	20
Fecal Coliform	1	4	7	3	4

Figure 4.6 : Bioaerosol Counts of Tuzla WWTP Aeration Unit

The activated sludge process, like all other biological treatment systems, relies on the removal of pollutants from wastewater through a series of biochemical reactions.

In this treatment plant, diffused aeration system is used for activated sludge process. Aeration unit is located near the final clarifier unit. This sampling point results could be affected by wind.

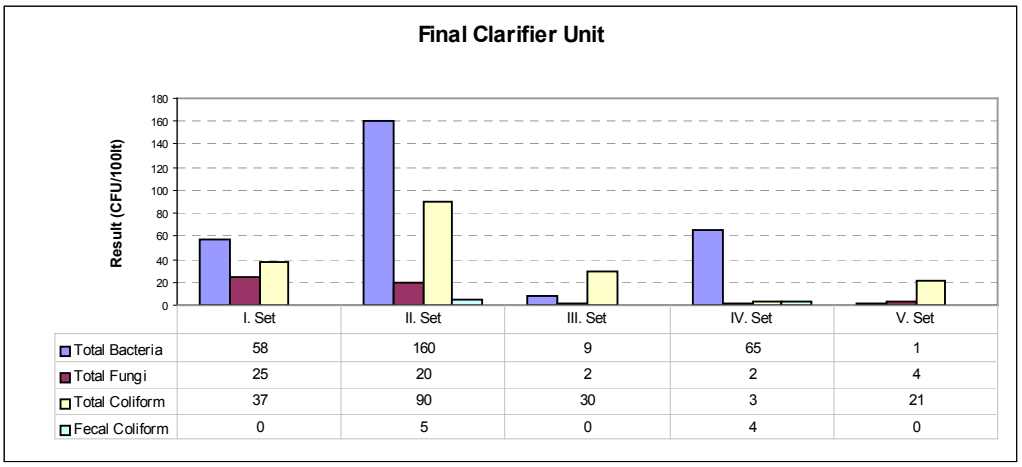
Because of the fine bubble aeration system, counts of this system are smaller than other forced aerated unit operations.



	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	57	110	36	140	120
Total Fungi	25	17	0	6	13
Total Coliform	20	65	26	67	90
Fecal Coliform	1	3	1	30	3

Figure 4.7 : Bioaerosol Counts of Sampling Point which is located between Aeration Unit and Final Clarifier

Results of this sampling point is greater than aeration unit and final clarifier sampling point results. Results can be influenced by the total effect of these unit processes.

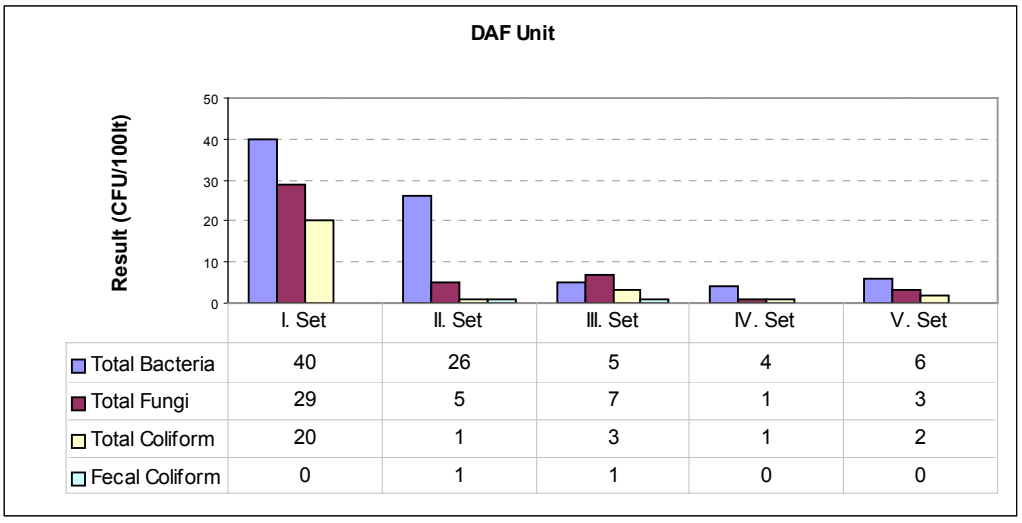


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	58	160	9	65	1
Total Fungi	25	20	2	2	4
Total Coliform	37	90	30	3	21
Fecal Coliform	0	5	0	4	0

Figure 4.8 : Bioaerosol Counts of Tuzla WWTP Final Clarifier Unit

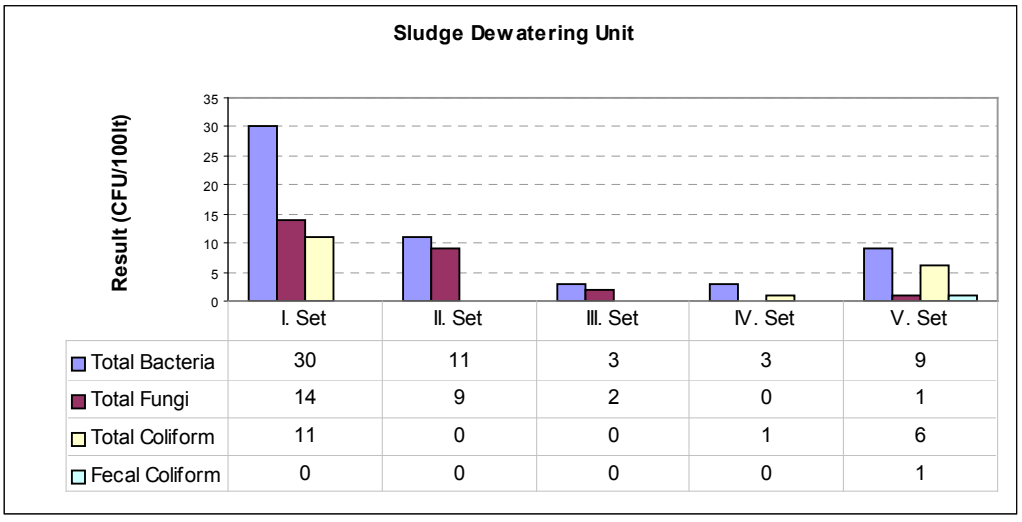
The function of this unit process is to seperate the activated sludge solids from the mixed liquor. Final clarifiers have rectangular shape and located beside the aeration tanks. These counts could be affected by the aeration tank emition.

In dissolved air flotation (DAF) systems, air is dissolved in the wastewater under a pressure of several atmospheres, followed by release of the pressure to te atmospheric level. The entire flow is held in a retention tank under pressure for several minutes to allow time for the air to dissolve. The pressurised flow is then admitted through a pressure-reducing valve to the flotation tank where the air comes out of solution in minute bubbles throughout the entire volume of liquid.



	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	40	26	5	4	6
Total Fungi	29	5	7	1	3
Total Coliform	20	1	3	1	2
Fecal Coliform	0	1	1	0	0

Figure 4.9 : Bioaerosol Counts of Tuzla WWTP DAF Unit

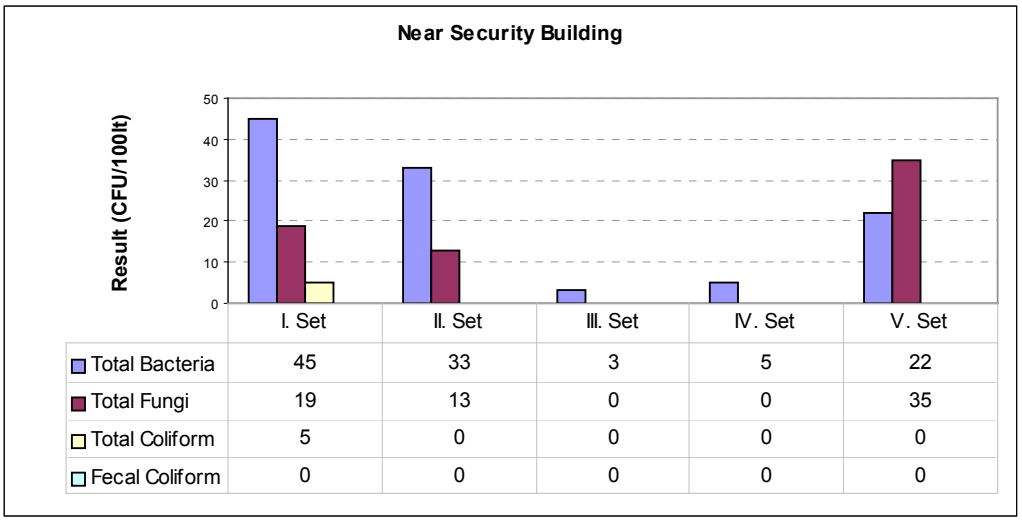


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	30	11	3	3	9
Total Fungi	14	9	2	0	1
Total Coliform	11	0	0	1	6
Fecal Coliform	0	0	0	0	1

Figure 4.10 : Bioaerosol Counts of Tuzla WWTP Sludge Dewatering Unit

Sludge dewatering is a mechanical unit operation used to reduce the moisture content of sludge. In Tuzla wastewater treatment plant mechanically dewatering devices are used for dewatering the sludge more quickly.

This system operates in a closed process line, in other words; this system operated under conditions which sludge is not directly contact with outdoor air. This principle reduces the number of the airborne microorganisms.

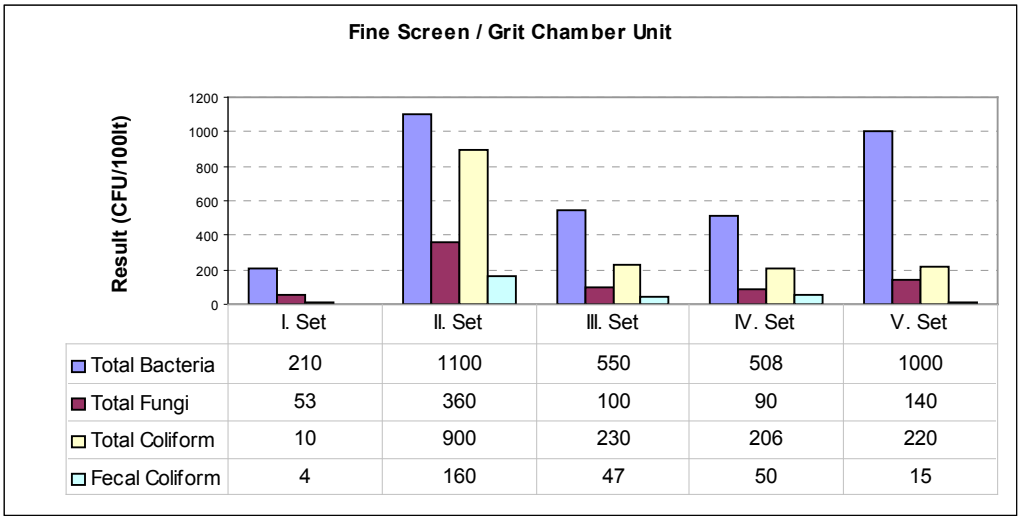


	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	45	33	3	5	22
Total Fungi	19	13	0	0	35
Total Coliform	5	0	0	0	0
Fecal Coliform	0	0	0	0	0

Figure 4.11 : Bioaerosol Counts of Sampling Point Near Tuzla WWTP Security Building

Security building is located in the plant boundary and it is not very close to the treatment units. This point could be affected by the wind effect.

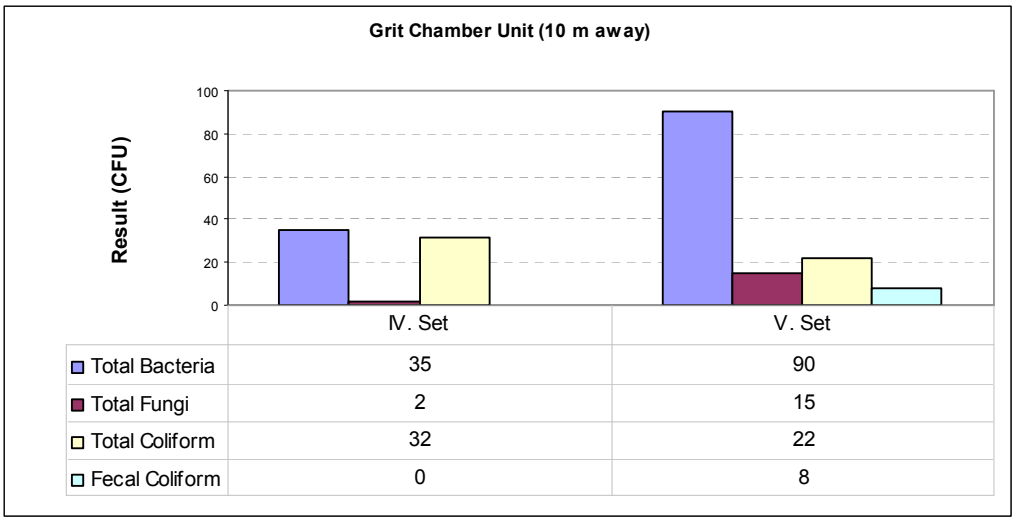
4.3.Airborne Microorganisms in the Paşaköy Biological Wastewater Treatment Plant



	I. Set	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	210	1100	550	508	1000
Total Fungi	53	360	100	90	140
Total Coliform	10	900	230	206	220
Fecal Coliform	4	160	47	50	15

Figure 4.12 : Bioaerosol Counts of Paşaköy WWTP Fine Screen / Grit Chamber Unit

Grit chambers and fine screens are constructed together. The results of the bioaerosol counts could be affected by the total effects of grit chambers and fine screens.

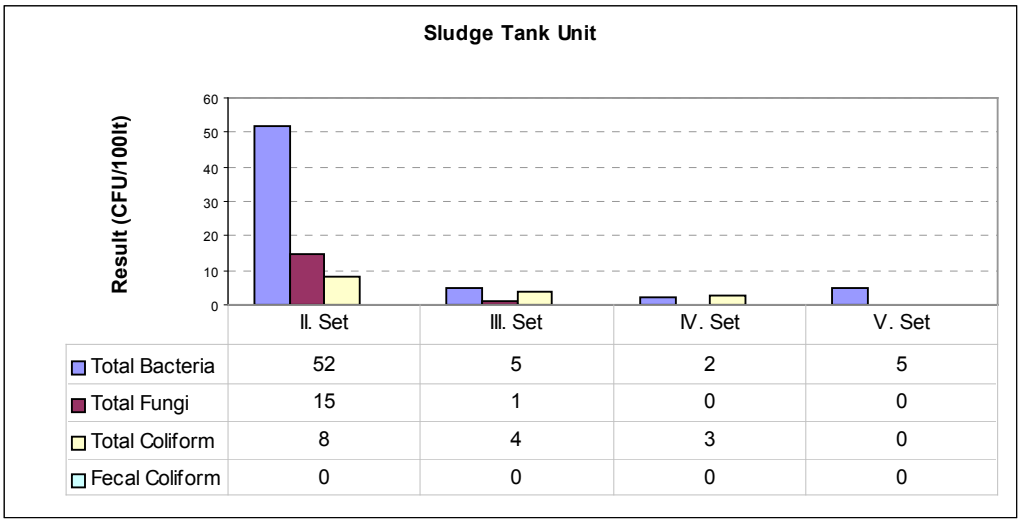


	IV. Set	V. Set
Total Bacteria	35	90
Total Fungi	2	15
Total Coliform	32	22
Fecal Coliform	0	8

Figure 4.13 : Bioaerosol Counts of Sampling Point 10 m away from Paşaköy WWTP Grit Chamber Unit

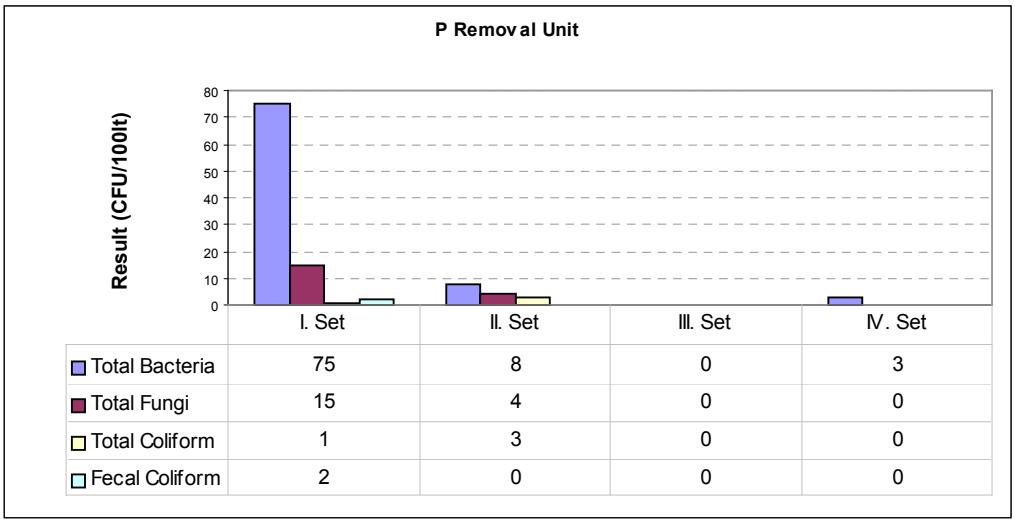
After the completion of three sets of measurement, it is concluded that, grit chambers emit more bioaerosol than other unit operations. In the IV. and V. sets of measurement it was decided to take samples from 10 m distance from grit chambers.

There is not any opeations near to grit chambers to affect the results of the counts. The results show that areas near dominant sources like grit chambers might be affected from these unit processes.



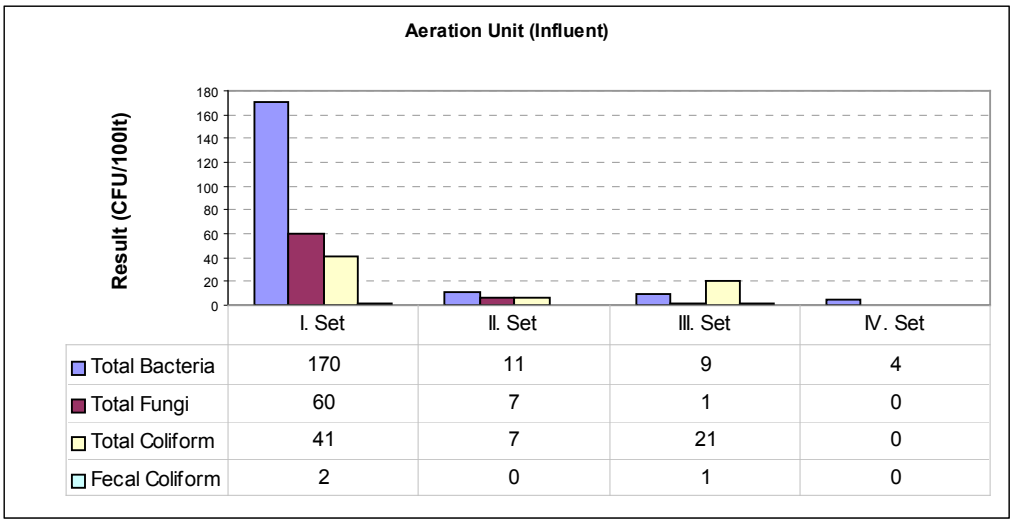
	II. Set	III. Set	IV. Set	V. Set
Total Bacteria	52	5	2	5
Total Fungi	15	1	0	0
Total Coliform	8	4	3	0
Fecal Coliform	0	0	0	0

Figure 4.14 : Bioaerosol Counts of Paşaköy WWTP Sludge Tank Unit



	I. Set	II. Set	III. Set	IV. Set
Total Bacteria	75	8	0	3
Total Fungi	15	4	0	0
Total Coliform	1	3	0	0
Fecal Coliform	2	0	0	0

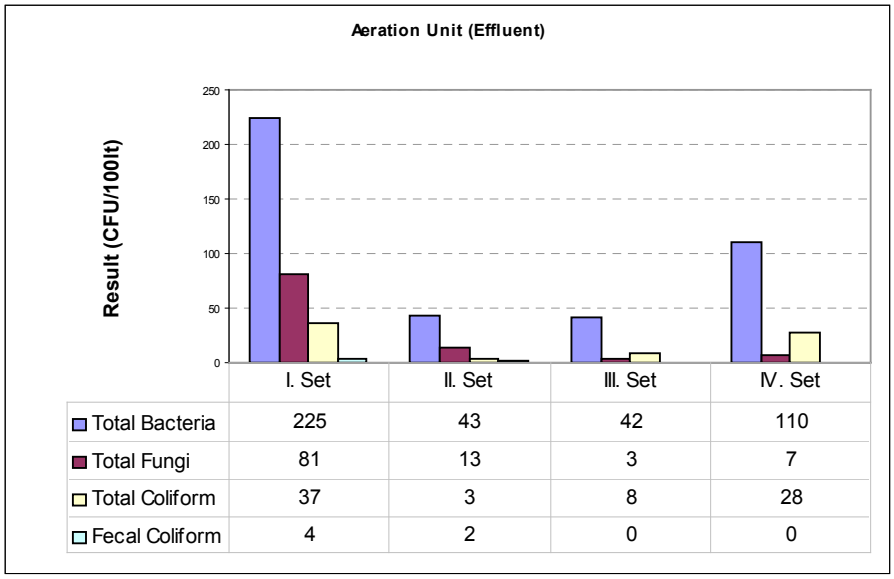
Figure 4.15 : Bioaerosol Counts of Paşaköy WWTP P Removal Unit



	I. Set	II. Set	III. Set	IV. Set
Total Bacteria	170	11	9	4
Total Fungi	60	7	1	0
Total Coliform	41	7	21	0
Fecal Coliform	2	0	1	0

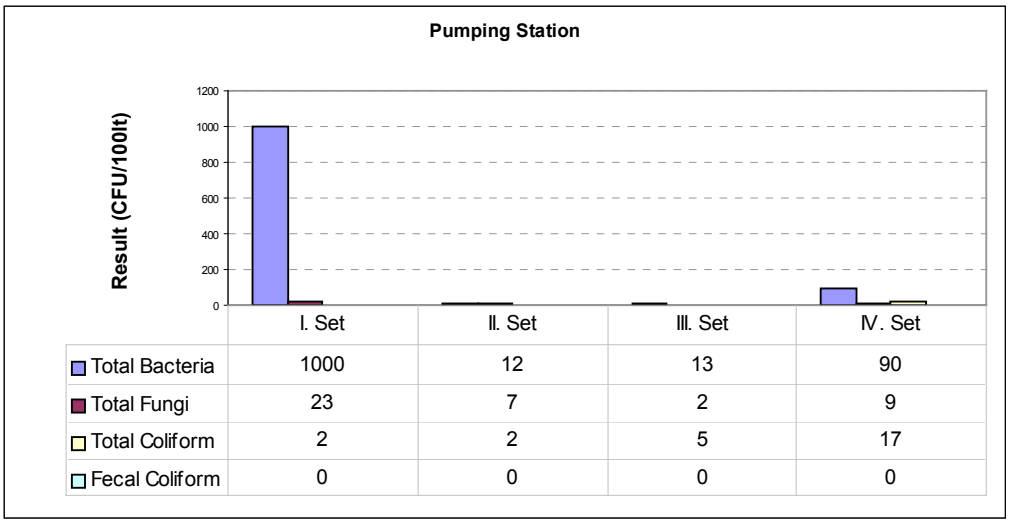
Figure 4.16 : Bioaerosol Counts of Paşaköy WWTP Aeration Unit (Influent)

Bio-P removal tank and aerated tanks are located as adjacent tanks. Count results could be effected by the emition of all the tanks.



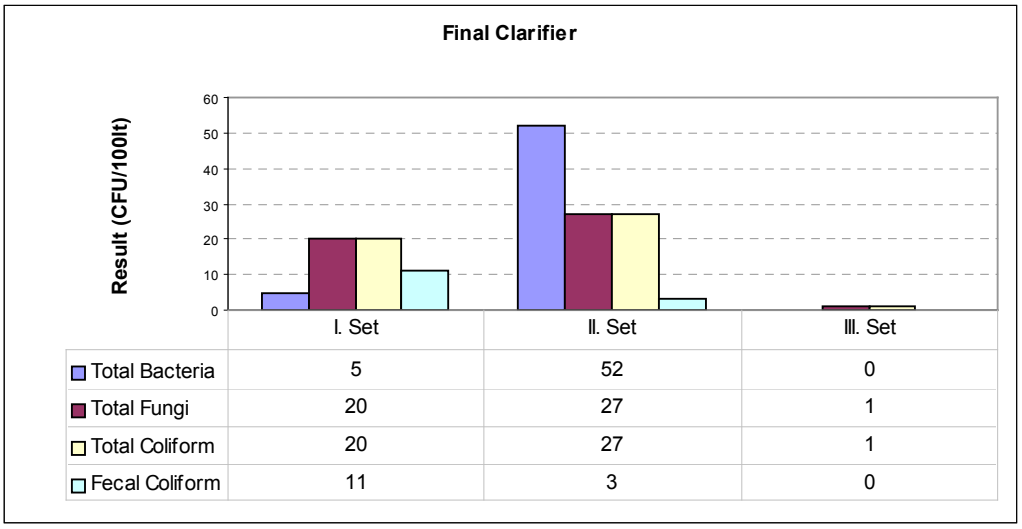
	I. Set	II. Set	III. Set	IV. Set
Total Bacteria	225	43	42	110
Total Fungi	81	13	3	7
Total Coliform	37	3	8	28
Fecal Coliform	4	2	0	0

Figure 4.17 : Bioaerosol Counts of Paşaköy WWTP Aeration Unit (Effluent)



	I. Set	II. Set	III. Set	IV. Set
Total Bacteria	1000	12	13	90
Total Fungi	23	7	2	9
Total Coliform	2	2	5	17
Fecal Coliform	0	0	0	0

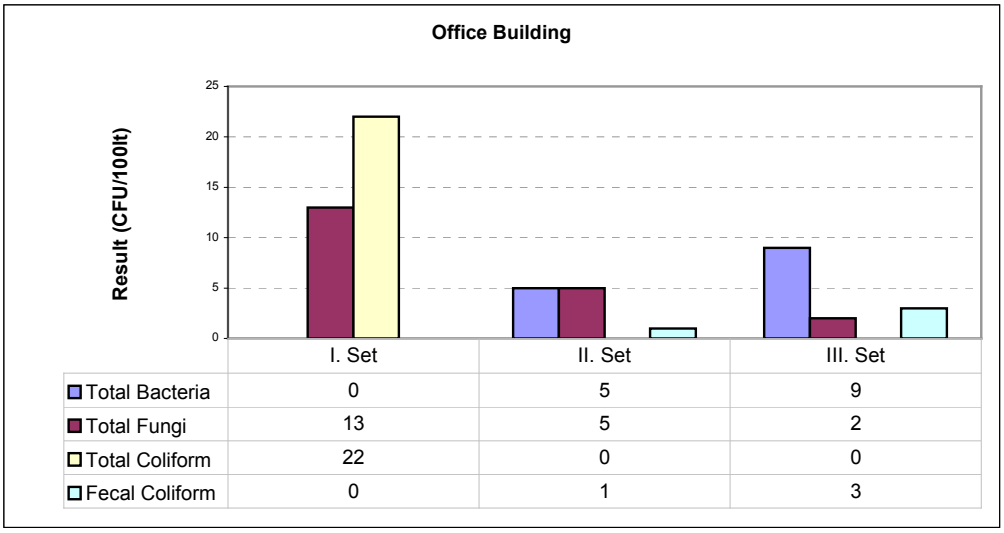
Figure 4.18 : Bioaerosol Counts of Paşaköy WWTP Pumping Station Unit



	I. Set	II. Set	III. Set
Total Bacteria	5	52	0
Total Fungi	20	27	1
Total Coliform	20	27	1
Fecal Coliform	11	3	0

Figure 4.19 : Bioaerosol Counts of Paşaköy WWTP Final Clarifier Unit

Final clarifier tanks are located relativeley far from other treatment units when it is compared with Tuzla wastewater treatment plant.



	I. Set	II. Set	III. Set
Total Bacteria	0	5	9
Total Fungi	13	5	2
Total Coliform	22	0	0
Fecal Coliform	0	1	3

Figure 4.20 : Bioaerosol Counts of Sampling Point Near Paşaköy WWTP Office Building

Paşaköy office building is located in the plant boundary and at the top of the small hill. Wind effect could transport the bioaerosols from treatment units to the office building area.

4.4.Comparison of the Results

Coarse screening unit counts show that the results are low when they compared with other treatment processes.

The number of airborne microorganisms emitted from grit chamber unit is greater than other treatment unit emissions. Because the number of airborne microorganisms was greatly influenced by grit chamber aeration system.

Counts of primary settling units are also low when compared to other processes.

Aeration tanks sample results was greater than many of the densities found outdoors at the wastewater treatment plants.

In general, datas obtained from this bioaerosol enumaration study are similar regarding unit processes. Consequently; with the wind effect, some of the locations yielded different counts observed during this study.

Currently, the highest numbers of airborne microorganisms are found in screening, grit chamber and aeration operations. Grit chamber emits highest number of

bioaerosols. The aeration used in this process generates bioaerosols. And, most of these operations are mechanical processes of untreated wastewater. As a result of this study, it is concluded that, mechanicaly aerated units emits much more bioaerosol than other processes.

Only the numbers of microorganisms that formed colonies were determined. These numbers are simple indicators of the microbial loads in the air, and they are useful to compare changes in the densities of airborne microorganisms and to detect locations that have high numbers. Obviously, lower microbial densities indicate that workers and people near the plant will be exposed to fewer airborne microorganisms, thereby reducing the potential for exposure to pathogens.

4.5.Overall Results, Recommendations for Future Studies

Duringthis study environmental applications like wastewater treatment are investigated. Different sources can be evaluated. Especially, composting and waste recycling, landfilling processes are the subject of primary concern as environmental applications.

There are several bioaerosol sampler available on the market. Different samplers and sampling methods can be used.

Identification study can be performed. Because knowing the types of microorganisms and controlling them in the atmospheric environment may play a role in preventing many infectious diseases.

Health follow-up studies for workers and near residents around the treatment plants should be performed.

Individual exposure to bioaerosols can best be evaluated by the use of personal aerosol monitors, as these samplers track the effects of human time-activity patterns.

Treatment plant designs has to be reviewed and bioaerosol elimination or reduction techniques has to be implemented. Some of the odor control systems can be modified to treat bioaerosols. Some of the treatment units can be covered such as grit chambers. Because these systems emit much more bioaerosol than other treatment processes and their size are relatively small.

There should be biological air monitoring stations or equipments in the treatment plants and in the cities.

Limits for biological pollutants should be setted.

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EK 1 : MICROBIOLOGICAL AIR SAMPLING RESULTS														
Plant Name	**Sampling Point**	**Nr**	**Agar**	**Sampling volume (lt)**	**Sample Nr**	**Date**	**Time**	**Weather**	**Wind Velocity min (m/sn)**	**Wind Velocity max (m/sn)**	**Temp. (°C)**	**Humd. (%)**	**Result (CFU)**
İSKİ Ataköy WWTP	Trickling Filter		Plate Count Agar	10	N0001	19.02.2006	10:09	Cloudy	NA	NA	5	65	6
"	"		Plate Count Agar	50	N0002	19.02.2006	10:25	Cloudy	NA	NA	5	65	55
"	"		Plate Count Agar	1000	N0003	19.02.2006	10:38	Cloudy	NA	NA	5	65	1350
"	"		Plate Count Agar	200	N0004	19.02.2006	10:43	Cloudy	NA	NA	5	65	180
"	Final Clarifier		Plate Count Agar	200	N0005	19.02.2006	10:53	Cloudy	NA	NA	5	65	32
"	Final Clarifier		Plate Count Agar	100	N0006	19.02.2006	11:15	Cloudy	NA	NA	5	65	16
"	Trickling Filter		Plate Count Agar	100	N0007	19.02.2006	11:38	Cloudy	NA	NA	6	64	62
"	Primary Settling		Plate Count Agar	100	N0008	19.02.2006	11:45	Cloudy	NA	NA	6	64	22
"	Primary Settling		Plate Count Agar	200	N0009	19.02.2006	11:54	Cloudy	NA	NA	6	64	95
"	Grit Chamber		Plate Count Agar	100	N0010	19.02.2006	12:08	Cloudy	NA	NA	6	64	98
"	Grit Chamber		Plate Count Agar	200	N0011	19.02.2006	12:18	Cloudy	NA	NA	6	64	900
"	Coarse Screen		Plate Count Agar	200	N0012	19.02.2006	12:26	Cloudy	NA	NA	6	64	52
İSKİ Ataköy WWTP	Coarse Screen		Plate Count Agar	100	N0013	19.02.2006	12:37	Cloudy	NA	NA	6	64	15

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	30 m away from trickling f.		Plate Count Agar	100	N0014	19.02.2006	12:48	Cloudy	NA	NA	6	64	23
"	30 m away from trickling f.		Plate Count Agar	200	N0015	19.02.2006	12:57	Cloudy	NA	NA	6	64	6000
"	Security Building		Plate Count Agar	100	N0016	19.02.2006	13:09	Cloudy	NA	NA	6	64	3500
"	Security Building		Plate Count Agar	200	N0017	19.02.2006	13:23	Cloudy	NA	NA	6	64	275
İTÜ Ayazağa	Env. Eng. Dep. Entrance		Plate Count Agar	200	N0018	19.02.2006	17:05	Cloudy	NA	NA	4	54	25
"	Env. Eng. Dep. Entrance		Plate Count Agar	100	N0019	19.02.2006	17:13	Cloudy	NA	NA	4	54	10
"	Env. Eng. Dep. Entrance		Plate Count Agar	100	N0020	19.02.2006	17:23	Cloudy	NA	NA	4	54	11
İSKİ Tuzla Biol. WWTP	Final Clarifier	1	Plate Count Agar	100	N 0021	07.04.2006	09:03	Part. Cloudy	1,50	2,40	18	46	58
“	"	1	Endo Agar	100	N 0022	07.04.2006	09:25	“	1,50	2,40	18	45	37
“	"	1	Saburaud Agar	100	N 0023	07.04.2006	09:32	“	1,50	2,40	18	45	25
“	"	1	Violet Red Agar	100	N 0024	07.04.2006	09:44	“	1,50	2,40	18	45	0
İSKİ Tuzla Biol. WWTP	Final Clarifier/ Aeration	2	Plate Count Agar	100	N 0025	07.04.2006	09:59	Part. Cloudy	1,00	1,90	19	44	57

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	2	Endo Agar	100	N 0026	07.04.2006	10:12	"	1,00	1,90	19	44	20
"	"	2	Saburaud Agar	100	N 0027	07.04.2006	10:21	"	1,00	1,90	19	44	25
"	"	2	Violet Red Agar	100	N 0028	07.04.2006	10:42	"	1,00	1,90	19	44	1
İSKİ Tuzla Biol. WWTP	Aeration	3	Plate Count Agar	100	N 0029	07.04.2006	10:50	Part. Cloudy	1,30	2,10	18	44	28
"	"	3	Endo Agar	100	N 0030	07.04.2006	10:59	"	1,30	2,10	18	44	10
"	"	3	Saburaud Agar	100	N 0031	07.04.2006	11:15	"	1,30	2,10	18	44	16
"	"	3	Violet Red Agar	100	N 0032	07.04.2006	11:28	"	1,30	2,10	18	44	1
İSKİ Tuzla Biol. WWTP	Gravity Settling	4	Plate Count Agar	100	N 0033	07.04.2006	11:40	Part. Cloudy	0,80	1,80	18	44	36
"	"	4	Endo Agar	100	N 0034	07.04.2006	11:51	"	0,80	1,80	18	44	7
"	"	4	Saburaud Agar	100	N 0035	07.04.2006	12:02	"	0,80	1,80	18	44	21
"	"	4	Violet Red Agar	100	N 0036	07.04.2006	12:13	"	0,80	1,80	18	44	5
İSKİ Tuzla Biol. WWTP	Grit Chamber	5	Plate Count Agar	100	N 0037	07.04.2006	12:25	Part. Cloudy	0,80	1,80	17	45	600
"	"	5	Endo Agar	100	N 0038	07.04.2006	12:32	"	0,80	1,80	17	45	175

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	5	Saburaud Agar	100	N 0039	07.04.2006	12:42	“	0,80	1,80	17	45	83
“	"	5	Violet Red Agar	100	N 0040	07.04.2006	12:51	“	0,80	1,80	17	45	2
İSKİ Tuzla Biol. WWTP	Coarse Screen	6	Plate Count Agar	100	N 0041	07.04.2006	13:17	Part. Cloudy	0,30	1,10	17	44	18
"	"	6	Endo Agar	100	N 0042	07.04.2006	13:26	"	0,30	1,10	17	44	11
"	"	6	Saburaud Agar	100	N 0043	07.04.2006	13:37	"	0,30	1,10	17	44	25
"	"	6	Violet Red Agar	100	N 0044	07.04.2006	13:43	"	0,30	1,10	17	44	0
İSKİ Tuzla Biol. WWTP	Sludge Dewatering	7	Plate Count Agar	100	N 0045	07.04.2006	13:58	Part. Cloudy	0,10	0.3	16	48	30
“	"	7	Endo Agar	100	N 0046	07.04.2006	14:05	“	0,10	0.3	16	48	11
“	"	7	Saburaud Agar	100	N 0047	07.04.2006	14:12	“	0,10	0.3	16	48	14
“	"	7	Violet Red Agar	100	N 0048	07.04.2006	14:17	“	0,10	0.3	16	48	0
İSKİ Tuzla Biol. WWTP	DAF	8	Plate Count Agar	100	N 0049	07.04.2006	14:25	Part. Cloudy	0,70	2,10	17	44	40
"	"	8	Endo Agar	100	N 0050	07.04.2006	14:30	"	0,70	2,10	17	44	20
"	"	8	Saburaud Agar	100	N 0051	07.04.2006	14:37	"	0,70	2,10	17	44	29

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	8	Violet Red Agar	100	N 0052	07.04.2006	14:43	"	0,70	2,10	17	44	0
İSKİ Tuzla Biol. WWTP	Security Building	9	Plate Count Agar	100	N 0053	07.04.2006	14:51	Part. Cloudy	0,20	1,70	18	44	45
"	"	9	Endo Agar	100	N 0054	07.04.2006	14:56	"	0,20	1,70	18	44	5
"	"	9	Saburaud Agar	100	N 0055	07.04.2006	15:02	"	0,20	1,70	18	44	19
"	"	9	Violet Red Agar	100	N 0056	07.04.2006	15:08	"	0,20	1,70	18	44	0
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber	1	Plate Count Agar	100	N 0057	07.04.2006	16:40	Cloudy	0,50	0,90	9	52	210
"	"	1	Endo Agar	100	N 0058	07.04.2006	16:47	"	0,50	0,90	9	52	10
"	"	1	Saburaud Agar	100	N 0059	07.04.2006	16:55	"	0,50	0,90	9	52	53
"	"	1	Violet Red Agar	100	N 0060	07.04.2006	17:01	"	0,50	0,90	9	52	4
İSKİ Paşaköy Biol. WWTP	Sludge Tank	2	Plate Count Agar	100	N 0061	07.04.2006	17:16	Cloudy	0,80	1,30	9	51	52
"	"	2	Endo Agar	100	N 0062	07.04.2006	17:23	"	0,80	1,30	9	51	8
"	"	2	Saburaud Agar	100	N 0063	07.04.2006	17:30	"	0,80	1,30	9	51	15
"	"	2	Violet Red Agar	100	N 0064	07.04.2006	17:35	"	0,80	1,30	9	51	0

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
İSKİ Paşaköy Biol. WWTP	P Removal Tank	3	Plate Count Agar	100	N 0065	07.04.2006	17:42	Cloudy	1,00	1,90	8	55	75
"	"	3	Endo Agar	100	N 0066	07.04.2006	17:47	"	1,00	1,90	8	55	1
"	"	3	Saburaud Agar	100	N 0067	07.04.2006	17:55	"	1,00	1,90	8	55	15
"	"	3	Violet Red Agar	100	N 0068	07.04.2006	18:00	"	1,00	1,90	8	55	2
İSKİ Paşaköy Biol. WWTP	Aeration (Influent)	4	Plate Count Agar	100	N 0069	07.04.2006	18:06	Cloudy	0,80	1,70	9	51	170
"	"	4	Endo Agar	100	N 0070	07.04.2006	18:09	"	0,80	1,70	9	51	41
"	"	4	Saburaud Agar	100	N 0071	07.04.2006	18:14	"	0,80	1,70	9	51	60
"	"	4	Violet Red Agar	100	N 0072	07.04.2006	18:19	"	0,80	1,70	9	51	2
İSKİ Paşaköy Biol. WWTP	Aeration (Effluent)	5	Plate Count Agar	100	N 0073	07.04.2006	18:25	Cloudy	1,10	1,80	8	52	225
"	"	5	Endo Agar	100	N 0074	07.04.2006	18:29	"	1,10	1,80	8	52	37
"	"	5	Saburaud Agar	100	N 0075	07.04.2006	18:35	"	1,10	1,80	8	52	81
"	"	5	Violet Red Agar	100	N 0076	07.04.2006	18:39	"	1,10	1,80	8	52	4
İSKİ Paşaköy Biol. WWTP	Pumping Station	6	Plate Count Agar	100	N 0077	07.04.2006	18:45	Cloudy	1,00	1,80	8	52	1000

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	6	Endo Agar	100	N 0078	07.04.2006	18:48	“	1,00	1,80	8	52	2
“	"	6	Saburaud Agar	100	N 0079	07.04.2006	18:52	“	1,00	1,80	8	52	23
“	"	6	Violet Red Agar	100	N 0080	07.04.2006	19:00	“	1,00	1,80	8	52	0
İSKİ Tuzla Biol. WWTP	Final Clarifier	1	Plate Count Agar	100	N 0081	08.04.2006	08:03	Clear	0,30	1,00	19	43	160
"	"	1	Endo Agar	100	N 0082	08.04.2006	08:16	"	0,30	1,00	19	43	90
"	"	1	Saburaud Agar	100	N 0083	08.04.2006	08:26	"	0,30	1,00	19	43	20
"	"	1	Violet Red Agar	100	N 0084	08.04.2006	08:35	"	0,30	1,00	19	43	5
İSKİ Tuzla Biol. WWTP	Final Clarifier/ Aeration	2	Plate Count Agar	100	N 0085	08.04.2006	08:45	Clear	0,30	1,00	19	43	110
“	"	2	Endo Agar	100	N 0086	08.04.2006	08:52	“	0,30	1,00	19	43	65
“	"	2	Saburaud Agar	100	N 0087	08.04.2006	09:00	“	0,30	1,00	19	43	17
“	"	2	Violet Red Agar	100	N 0088	08.04.2006	09:09	“	0,30	1,00	19	43	3
İSKİ Tuzla Biol. WWTP	Aeration	3	Plate Count Agar	100	N 0089	08.04.2006	09:15	Clear	0,30	1,00	19	43	210
"	"	3	Endo Agar	100	N 0090	08.04.2006	09:23	"	0,30	1,00	19	43	105

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	3	Saburaud Agar	100	N 0091	08.04.2006	09:34	"	0,30	1,00	19	43	32
"	"	3	Violet Red Agar	100	N 0092	08.04.2006	09:42	"	0,30	1,00	19	43	4
İSKİ Tuzla Biol. WWTP	Gravity Settling	4	Plate Count Agar	100	N 0093	08.04.2006	09:55	Clear	0,40	0,80	18	42	26
"	"	4	Endo Agar	100	N 0094	08.04.2006	10:03	"	0,40	0,80	18	42	2
"	"	4	Saburaud Agar	100	N 0095	08.04.2006	10:09	"	0,40	0,80	18	42	2
"	"	4	Violet Red Agar	100	N 0096	08.04.2006	10:14	"	0,40	0,80	18	42	0
İSKİ Tuzla Biol. WWTP	Grit Chamber	5	Plate Count Agar	100	N 0097	08.04.2006	10:25	Clear	0,50	1,30	18	45	1250
"	"	5	Endo Agar	100	N 0098	08.04.2006	10:29	"	0,50	1,30	18	45	4000
"	"	5	Saburaud Agar	100	N 0099	08.04.2006	10:34	"	0,50	1,30	18	45	400
"	"	5	Violet Red Agar	100	N 0100	08.04.2006	10:41	"	0,50	1,30	18	45	355
İSKİ Tuzla Biol. WWTP	Coarse Screen	6	Plate Count Agar	100	N 0101	08.04.2006	10:55	Clear	0,50	1,10	18	44	28
"	"	6	Endo Agar	100	N 0102	08.04.2006	11:05	"	0,50	1,10	18	44	12
"	"	6	Saburaud Agar	100	N 0103	08.04.2006	11:11	"	0,50	1,10	18	44	12

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	6	Violet Red Agar	100	N 0104	08.04.2006	11:19	“	0,50	1,10	18	44	4
İSKİ Tuzla Biol. WWTP	Sludge Dewatering	7	Plate Count Agar	100	N 0105	08.04.2006	11:27	Clear	0,20	0,40	16	46	11
"	"	7	Endo Agar	100	N 0106	08.04.2006	11:33	"	0,20	0,40	16	46	0
"	"	7	Saburaud Agar	100	N 0107	08.04.2006	11:39	"	0,20	0,40	16	46	9
"	"	7	Violet Red Agar	100	N 0108	08.04.2006	11:45	"	0,20	0,40	16	46	0
İSKİ Tuzla Biol. WWTP	DAF	8	Plate Count Agar	100	N 0109	08.04.2006	11:58	Clear	0,60	1,40	17	43	26
“	"	8	Endo Agar	100	N 0110	08.04.2006	12:04	“	0,60	1,40	17	43	1
“	"	8	Saburaud Agar	100	N 0111	08.04.2006	12:11	“	0,60	1,40	17	43	5
“	"	8	Violet Red Agar	100	N 0112	08.04.2006	12:17	“	0,60	1,40	17	43	1
İSKİ Tuzla Biol. WWTP	Security Building	9	Plate Count Agar	100	N 0113	08.04.2006	12:30	Clear	0,60	1,30	17	43	33
"	"	9	Endo Agar	100	N 0114	08.04.2006	12:36	"	0,60	1,30	17	43	0
"	"	9	Saburaud Agar	100	N 0115	08.04.2006	12:43	"	0,60	1,30	17	43	13
"	"	9	Violet Red Agar	100	N 0116	08.04.2006	12:49	"	0,60	1,30	17	43	0

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber	1	Plate Count Agar	100	N 0117	08.04.2006	15:06	Clear	0,90	1,20	13	46	1100
"	"	1	Endo Agar	100	N 0118	08.04.2006	15:12	"	0,90	1,20	13	46	900
"	"	1	Saburaud Agar	100	N 0119	08.04.2006	15:17	"	0,90	1,20	13	46	360
"	"	1	Violet Red Agar	100	N 0120	08.04.2006	15:27	"	0,90	1,20	13	46	160
İSKİ Paşaköy Biol. WWTP	Sludge Tank	2	Plate Count Agar	100	N 0121	08.04.2006	15:39	Clear	0,80	1,30	12	45	5
"	"	2	Endo Agar	100	N 0122	08.04.2006	15:43	"	0,80	1,30	12	45	4
"	"	2	Saburaud Agar	100	N 0123	08.04.2006	15:49	"	0,80	1,30	12	45	1
"	"	2	Violet Red Agar	100	N 0124	08.04.2006	16:00	"	0,80	1,30	12	45	0
İSKİ Paşaköy Biol. WWTP	P Removal Tank	3	Plate Count Agar	100	N 0125	08.04.2006	16:12	Clear	0,70	1,00	11	43	8
"	"	3	Endo Agar	100	N 0126	08.04.2006	16:18	"	0,70	1,00	11	43	3
"	"	3	Saburaud Agar	100	N 0127	08.04.2006	16:23	"	0,70	1,00	11	43	4
"	"	3	Violet Red Agar	100	N 0128	08.04.2006	16:29	"	0,70	1,00	11	43	0
İSKİ Paşaköy Biol. WWTP	Aeration (Influent)	4	Plate Count Agar	100	N 0129	08.04.2006	16:39	Clear	0,70	1,00	10	43	11

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	4	Endo Agar	100	N 0130	08.04.2006	16:47	"	0,70	1,00	10	43	7
“	"	4	Saburaud Agar	100	N 0131	08.04.2006	16:53	"	0,70	1,00	10	43	7
“	"	4	Violet Red Agar	100	N 0132	08.04.2006	16:59	"	0,70	1,00	10	43	0
İSKİ Paşaköy Biol. WWTP	Aeration (Effluent)	5	Plate Count Agar	100	N 0133	08.04.2006	17:05	Clear	0,70	1,00	11	43	43
"	"	5	Endo Agar	100	N 0134	08.04.2006	17:12	“	0,70	1,00	11	43	3
"	"	5	Saburaud Agar	100	N 0135	08.04.2006	17:19	“	0,70	1,00	11	43	13
"	"	5	Violet Red Agar	100	N 0136	08.04.2006	17:26	“	0,70	1,00	11	43	2
İSKİ Paşaköy Biol. WWTP	Pumping Station	6	Plate Count Agar	100	N 0137	08.04.2006	17:37	Clear	0,70	1,10	10	42	12
“	"	6	Endo Agar	100	N 0138	08.04.2006	17:43	"	0,70	1,10	10	42	2
“	"	6	Saburaud Agar	100	N 0139	08.04.2006	17:50	"	0,70	1,10	10	42	7
“	"	6	Violet Red Agar	100	N 0140	08.04.2006	17:56	"	0,70	1,10	10	42	0
İSKİ Paşaköy Biol. WWTP	Final Clarifier	7	Plate Count Agar	100	N 0141	08.04.2006	18:09	Clear	0,60	1,10	10	42	5
"	"	7	Endo Agar	100	N 0142	08.04.2006	18:16	“	0,60	1,10	10	42	20

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	7	Saburaud Agar	100	N 0143	08.04.2006	18:26	"	0,60	1,10	10	42	26
"	"	7	Violet Red Agar	100	N 0144	08.04.2006	18:35	"	0,60	1,10	10	42	11
İSKİ Paşaköy Biol. WWTP	Office Building	8	Plate Count Agar	100	N 0145	08.04.2006	18:45	Clear	0,50	1,00	10	40	0
"	"	8	Endo Agar	100	N 0146	08.04.2006	18:51	"	0,50	1,00	10	40	22
"	"	8	Saburaud Agar	100	N 0147	08.04.2006	18:58	"	0,50	1,00	10	40	13
"	"	8	Violet Red Agar	100	N 0148	08.04.2006	19:03	"	0,50	1,00	10	40	0
İSKİ Tuzla Biol. WWTP	Final Clarifier	1	Plate Count Agar	100	N 0149	09.04.2006	08:07	Cloudy	1,20	2,20	9	49	9
"	"	1	Endo Agar	100	N 0150	09.04.2006	08:12	"	1,20	2,20	9	49	30
"	"	1	Saburaud Agar	100	N 0151	09.04.2006	08:16	"	1,20	2,20	9	49	2
"	"	1	Violet Red Agar	100	N 0152	09.04.2006	08:21	"	1,20	2,20	9	49	0
İSKİ Tuzla Biol. WWTP	Final Clarifier/ Aeration	2	Plate Count Agar	100	N 0153	09.04.2006	08:32	Cloudy	1,20	2,20	9	49	36
"	"	2	Endo Agar	100	N 0154	09.04.2006	08:37	"	1,20	2,20	9	49	26
"	"	2	Saburaud Agar	100	N 0155	09.04.2006	08:43	"	1,20	2,20	9	49	0

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	2	Violet Red Agar	100	N 0156	09.04.2006	08:47	"	1,20	2,20	9	49	1
İSKİ Tuzla Biol. WWTP	Aeration	3	Plate Count Agar	100	N 0157	09.04.2006	08:55	Cloudy	1,20	2,00	9	49	9
"	"	3	Endo Agar	100	N 0158	09.04.2006	08:59	"	1,20	2,00	9	49	35
"	"	3	Saburaud Agar	100	N 0159	09.04.2006	09:05	"	1,20	2,00	9	49	10
"	"	3	Violet Red Agar	100	N 0160	09.04.2006	09:09	"	1,20	2,00	9	49	7
İSKİ Tuzla Biol. WWTP	Gravity Settling	4	Plate Count Agar	100	N 0161	09.04.2006	09:17	Cloudy	0,80	1,50	8	49	1
"	"	4	Endo Agar	100	N 0162	09.04.2006	09:24	"	0,80	1,50	8	49	0
"	"	4	Saburaud Agar	100	N 0163	09.04.2006	09:28	"	0,80	1,50	8	49	0
"	"	4	Violet Red Agar	100	N 0164	09.04.2006	09:34	"	0,80	1,50	8	49	1
İSKİ Tuzla Biol. WWTP	Grit Chamber	5	Plate Count Agar	100	N 0165	09.04.2006	09:45	Cloudy	0,70	1,60	8	48	1200
"	"	5	Endo Agar	100	N 0166	09.04.2006	09:49	"	0,70	1,60	8	48	400
"	"	5	Saburaud Agar	100	N 0167	09.04.2006	09:55	"	0,70	1,60	8	48	320
"	"	5	Violet Red Agar	100	N 0168	09.04.2006	10:05	"	0,70	1,60	8	48	80

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
İSKİ Tuzla Biol. WWTP	Coarse Screen	6	Plate Count Agar	100	N 0169	09.04.2006	10:17	Cloudy	0,30	0,90	8	47	3
"	"	6	Endo Agar	100	N 0170	09.04.2006	10:23	"	0,30	0,90	8	47	0
"	"	6	Saburaud Agar	100	N 0171	09.04.2006	10:29	"	0,30	0,90	8	47	3
"	"	6	Violet Red Agar	100	N 0172	09.04.2006	10:34	"	0,30	0,90	8	47	0
İSKİ Tuzla Biol. WWTP	Sludge Dewatering	7	Plate Count Agar	100	N 0173	09.04.2006	10:40	Cloudy	0,20	0,60	8	46	3
“	"	7	Endo Agar	100	N 0174	09.04.2006	10:45	“	0,20	0,60	8	46	0
“	"	7	Saburaud Agar	100	N 0175	09.04.2006	10:50	“	0,20	0,60	8	46	2
“	"	7	Violet Red Agar	100	N 0176	09.04.2006	10:54	“	0,20	0,60	8	46	0
İSKİ Tuzla Biol. WWTP	DAF	8	Plate Count Agar	100	N 0177	09.04.2006	11:06	Cloudy	0,80	1,60	9	49	5
"	"	8	Endo Agar	100	N 0178	09.04.2006	11:14	"	0,80	1,60	9	49	3
"	"	8	Saburaud Agar	100	N 0179	09.04.2006	11:19	"	0,80	1,60	9	49	7
"	"	8	Violet Red Agar	100	N 0180	09.04.2006	11:27	"	0,80	1,60	9	49	1
İSKİ Tuzla Biol. WWTP	Security Building	9	Plate Count Agar	100	N 0181	09.04.2006	11:37	Cloudy	0,70	1,60	9	48	3

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	9	Endo Agar	100	N 0182	09.04.2006	11:43	“	0,70	1,60	9	48	0
“	"	9	Saburaud Agar	100	N 0183	09.04.2006	11:49	“	0,70	1,60	9	48	0
“	"	9	Violet Red Agar	100	N 0184	09.04.2006	11:55	“	0,70	1,60	9	48	0
İSKİ Tuzla Biol. WWTP	Drainage Channel	10	Plate Count Agar	100	N 0185	09.04.2006	12:08	Cloudy	0,70	1,60	9	47	1000
"	"	10	Endo Agar	100	N 0186	09.04.2006	12:16	"	0,70	1,60	9	47	800
"	"	10	Saburaud Agar	100	N 0187	09.04.2006	12:19	"	0,70	1,60	9	47	47
"	"	10	Violet Red Agar	100	N 0188	09.04.2006	12:24	"	0,70	1,60	9	47	70
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber	1	Plate Count Agar	100	N 0189	09.04.2006	15:35	Cloudy	1,50	2,10	7	56	550
"	"	1	Endo Agar	100	N 0190	09.04.2006	15:39	“	1,50	2,10	7	56	230
"	"	1	Saburaud Agar	100	N 0191	09.04.2006	15:45	“	1,50	2,10	7	56	100
"	"	1	Violet Red Agar	100	N 0192	09.04.2006	15:52	“	1,50	2,10	7	56	47
İSKİ Paşaköy Biol. WWTP	Sludge Tank	2	Plate Count Agar	100	N 0193	09.04.2006	16:03	Cloudy	1,10	1,60	8	55	2
“	"	2	Endo Agar	100	N 0194	09.04.2006	16:08	"	1,10	1,60	8	55	3

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
“	"	2	Saburaud Agar	100	N 0195	09.04.2006	16:13	"	1,10	1,60	8	55	0
“	"	2	Violet Red Agar	100	N 0196	09.04.2006	16:17	"	1,10	1,60	8	55	0
İSKİ Paşaköy Biol. WWTP	P Removal Tank	3	Plate Count Agar	100	N 0197	09.04.2006	16:28	Cloudy	0,90	1,50	8	54	0
"	"	3	Endo Agar	100	N 0198	09.04.2006	16:35	“	0,90	1,50	8	54	0
"	"	3	Saburaud Agar	100	N 0199	09.04.2006	16:38	“	0,90	1,50	8	54	0
"	"	3	Violet Red Agar	100	N 0200	09.04.2006	16:42	“	0,90	1,50	8	54	0
İSKİ Paşaköy Biol. WWTP	DAF	9	Plate Count Agar	100	N 0201	09.04.2006	16:51	Cloudy	0,80	1,60	8	54	2
“	"	9	Endo Agar	100	N 0202	09.04.2006	16:58	"	0,80	1,60	8	54	0
“	"	9	Saburaud Agar	100	N 0203	09.04.2006	17:02	"	0,80	1,60	8	54	4
“	"	9	Violet Red Agar	100	N 0204	09.04.2006	17:05	"	0,80	1,60	8	54	0
İSKİ Paşaköy Biol. WWTP	Aeration (Influent)	4	Plate Count Agar	100	N 0205	09.04.2006	17:16	Cloudy	0,70	1,70	8	53	9
"	"	4	Endo Agar	100	N 0206	09.04.2006	17:23	“	0,70	1,70	8	53	21
"	"	4	Saburaud Agar	100	N 0207	09.04.2006	17:28	“	0,70	1,70	8	53	2

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	4	Violet Red Agar	100	N 0208	09.04.2006	17:32	“	0,70	1,70	8	53	1
İSKİ Paşaköy Biol. WWTP	Aeration (Effluent)	5	Plate Count Agar	100	N 0209	09.04.2006	17:44	Cloudy	0,70	1,60	8	52	42
“	"	5	Endo Agar	100	N 0210	09.04.2006	17:48	"	0,70	1,60	8	52	8
“	"	5	Saburaud Agar	100	N 0211	09.04.2006	17:54	"	0,70	1,60	8	52	3
“	"	5	Violet Red Agar	100	N 0212	09.04.2006	17:58	"	0,70	1,60	8	52	0
İSKİ Paşaköy Biol. WWTP	Pumping Station	6	Plate Count Agar	100	N 0213	09.04.2006	18:10	Cloudy	0,70	0,90	8	51	13
"	"	6	Endo Agar	100	N 0214	09.04.2006	18:13	“	0,70	0,90	8	51	5
"	"	6	Saburaud Agar	100	N 0215	09.04.2006	18:16	“	0,70	0,90	8	51	2
"	"	6	Violet Red Agar	100	N 0216	09.04.2006	18:19	“	0,70	0,90	8	51	0
İSKİ Paşaköy Biol. WWTP	Final Clarifier	7	Plate Count Agar	100	N 0217	09.04.2006	18:26	Cloudy	0,70	1,20	8	50	52
“	"	7	Endo Agar	100	N 0218	09.04.2006	18:29	"	0,70	1,20	8	50	27
“	"	7	Saburaud Agar	100	N 0219	09.04.2006	18:35	"	0,70	1,20	8	50	7
“	"	7	Violet Red Agar	100	N 0220	09.04.2006	18:42	"	0,70	1,20	8	50	3

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
İSKİ Paşaköy Biol. WWTP	Office Building	8	Plate Count Agar	100	N 0221	09.04.2006	18:54	Cloudy	0,30	1,20	9	51	5
"	"	8	Endo Agar	100	N 0222	09.04.2006	19:03	"	0,30	1,20	9	51	0
"	"	8	Saburaud Agar	100	N 0223	09.04.2006	19:06	"	0,30	1,20	9	51	5
"	"	8	Violet Red Agar	100	N 0224	09.04.2006	19:12	"	0,30	1,20	9	51	1
İSKİ Paşaköy Biol. WWTP	1 km away		Plate Count Agar	100	N 0225	09.04.2006	19:45	Cloudy	0,80	1,70	8	54	3
"	"		Endo Agar	100	N 0226	09.04.2006	19:48	"	0,80	1,70	8	54	0
"	"		Saburaud Agar	100	N 0227	09.04.2006	19:52	"	0,80	1,70	8	54	2
"	"		Violet Red Agar	100	N 0228	09.04.2006	19:57	"	0,80	1,70	8	54	1
Kadıköy	Downtown		Plate Count Agar	100	N 0229	09.04.2006	21:34	Cloudy	0,30	0,50	9	43	6
"	"		Endo Agar	100	N 0230	09.04.2006	21:38	"	0,30	0,50	9	43	0
"	"		Saburaud Agar	100	N 0231	09.04.2006	21:43	"	0,30	0,50	9	43	0
"	"		Violet Red Agar	100	N 0232	09.04.2006	21:47	"	0,30	0,50	9	43	0
İSKİ Tuzla Biol. WWTP	Final Clarifier	1	Plate Count Agar	100	N 0233	06.05.2006	09:05	Part. Cloudy	0,20	0,60	14	40	65

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	1	Endo Agar	100	N 0234	06.05.2006	09:21	"	0,20	0,60	14	40	3
"	"	1	Saburaud Agar	100	N 0235	06.05.2006	09:31	"	0,20	0,60	14	40	2
"	"	1	Violet Red Agar	100	N 0236	06.05.2006	09:35	"	0,20	0,60	14	40	4
İSKİ Tuzla Biol. WWTP	Final Clarifier/ Aeration	2	Plate Count Agar	100	N 0237	06.05.2006	09:43	Part. Cloudy	0,20	0,60	14	40	140
"	"	2	Endo Agar	100	N 0238	06.05.2006	09:47	"	0,20	0,60	14	40	67
"	"	2	Saburaud Agar	100	N 0239	06.05.2006	09:50	"	0,20	0,60	14	40	6
"	"	2	Violet Red Agar	100	N 0240	06.05.2006	09:55	"	0,20	0,60	14	40	30
İSKİ Tuzla Biol. WWTP	Aeration	3	Plate Count Agar	100	N 0241	06.05.2006	10:00	Part. Cloudy	0,20	0,60	14	40	28
"	"	3	Endo Agar	100	N 0242	06.05.2006	10:13	"	0,20	0,60	14	40	10
"	"	3	Saburaud Agar	100	N 0243	06.05.2006	10:16	"	0,20	0,60	14	40	33
"	"	3	Violet Red Agar	100	N 0244	06.05.2006	10:20	"	0,20	0,60	14	40	3
İSKİ Tuzla Biol. WWTP	Gravity Settling	4	Plate Count Agar	100	N 0245	06.05.2006	10:29	Part. Cloudy	0,30	0,80	14	40	53
"	"	4	Endo Agar	100	N 0246	06.05.2006	10:33	"	0,30	0,80	14	40	24

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	4	Saburaud Agar	100	N 0247	06.05.2006	10:37	"	0,30	0,80	14	40	19
"	"	4	Violet Red Agar	100	N 0248	06.05.2006	10:40	"	0,30	0,80	14	40	0
İSKİ Tuzla Biol. WWTP	Grit Chamber	5	Plate Count Agar	100	N 0249	06.05.2006	10:48	Part. Cloudy	0,30	0,40	14	40	2000
"	"	5	Endo Agar	100	N 0250	06.05.2006	10:53	"	0,30	0,40	15	40	1200
"	"	5	Saburaud Agar	100	N 0251	06.05.2006	10:57	"	0,30	0,40	15	40	140
"	"	5	Violet Red Agar	100	N 0252	06.05.2006	11:00	"	0,30	0,40	15	40	75
İSKİ Tuzla Biol. WWTP	Fine Screen	10	Plate Count Agar	100	N 0253	06.05.2006	11:10	Part. Cloudy	NA	NA	16	40	350
"	"	10	Endo Agar	100	N 0254	06.05.2006	11:13	"	NA	NA	16	40	800
"	"	10	Saburaud Agar	100	N 0255	06.05.2006	11:16	"	NA	NA	16	40	240
"	"	10	Violet Red Agar	100	N 0256	06.05.2006	11:20	"	NA	NA	16	40	47
İSKİ Tuzla Biol. WWTP	Coarse Screen	6	Plate Count Agar	100	N 0257	06.05.2006	11:26	Part. Cloudy	0,50	0,70	16	38	8
"	"	6	Endo Agar	100	N 0258	06.05.2006	11:30	"	0,50	0,70	16	38	3
"	"	6	Saburaud Agar	100	N 0259	06.05.2006	11:34	"	0,50	0,70	16	38	2

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	6	Violet Red Agar	100	N 0260	06.05.2006	11:37	"	0,50	0,70	16	38	0
İSKİ Tuzla Biol. WWTP	Sludge Dewatering	7	Plate Count Agar	100	N 0261	06.05.2006	11:46	Part. Cloudy	0,30	0,40	16	40	3
"	"	7	Endo Agar	100	N 0262	06.05.2006	11:49	"	0,30	0,40	16	40	1
"	"	7	Saburaud Agar	100	N 0263	06.05.2006	11:52	"	0,30	0,40	16	40	0
"	"	7	Violet Red Agar	100	N 0264	06.05.2006	11:55	"	0,30	0,40	16	40	0
İSKİ Tuzla Biol. WWTP	DAF	8	Plate Count Agar	100	N 0265	06.05.2006	12:07	Part. Cloudy	0,50	0,80	16	39	4
"	"	8	Endo Agar	100	N 0266	06.05.2006	12:11	"	0,50	0,80	16	39	1
"	"	8	Saburaud Agar	100	N 0267	06.05.2006	12:17	"	0,50	0,80	16	39	1
"	"	8	Violet Red Agar	100	N 0268	06.05.2006	12:21	"	0,50	0,80	16	39	0
İSKİ Tuzla Biol. WWTP	Security Building	9	Plate Count Agar	100	N 0269	06.05.2006	12:33	Part. Cloudy	0,50	0,80	17	39	5
"	"	9	Endo Agar	100	N 0270	06.05.2006	12:36	"	0,50	0,80	17	39	0
"	"	9	Saburaud Agar	100	N 0271	06.05.2006	12:39	"	0,50	0,80	17	39	0
"	"	9	Violet Red Agar	100	N 0272	06.05.2006	12:45	"	0,50	0,80	17	39	0

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
Tuzla	1 km away		Plate Count Agar	100	N 0273	06.05.2006	13:15	Part. Cloudy	0,30	0,50	17	39	47
"	"		Endo Agar	100	N 0274	06.05.2006	13:22	"	0,30	0,50	17	39	1
"	"		Saburaud Agar	100	N 0275	06.05.2006	13:27	"	0,30	0,50	17	39	8
"	"		Violet Red Agar	100	N 0276	06.05.2006	13:32	"	0,30	0,50	17	39	0
İSKİ Tuzla Biol. WWTP	Final Clarifier	1	Plate Count Agar	100	N 0277	06.05.2006	13:40	Part. Cloudy	0,40	0,70	17	39	1
"	"	1	Endo Agar	100	N 0278	06.05.2006	13:44	"	0,40	0,70	17	39	21
"	"	1	Saburaud Agar	100	N 0279	06.05.2006	13:47	"	0,40	0,70	17	39	4
"	"	1	Violet Red Agar	100	N 0280	06.05.2006	13:50	"	0,40	0,70	17	39	0
İSKİ Tuzla Biol. WWTP	Final Clarifier/ Aeration	2	Plate Count Agar	100	N 0281	06.05.2006	13:53	Part. Cloudy	0,40	0,70	17	39	120
"	"	2	Endo Agar	100	N 0282	06.05.2006	13:56	"	0,40	0,70	17	39	90
"	"	2	Saburaud Agar	100	N 0283	06.05.2006	13:58	"	0,40	0,70	17	39	13
"	"	2	Violet Red Agar	100	N 0284	06.05.2006	14:00	"	0,40	0,70	17	39	3
İSKİ Tuzla Biol. WWTP	Aeration	3	Plate Count Agar	100	N 0285	06.05.2006	14:05	Part. Cloudy	0,40	0,70	17	39	55

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	3	Endo Agar	100	N 0286	06.05.2006	14:08	"	0,40	0,70	17	39	20
"	"	3	Saburaud Agar	100	N 0287	06.05.2006	14:11	"	0,40	0,70	17	39	14
"	"	3	Violet Red Agar	100	N 0288	06.05.2006	14:14	"	0,40	0,70	17	39	4
İSKİ Tuzla Biol. WWTP	Gravity Settling	4	Plate Count Agar	100	N 0289	06.05.2006	14:20	Part. Cloudy	0,40	0,70	17	41	10
"	"	4	Endo Agar	100	N 0290	06.05.2006	14:23	"	0,40	0,70	17	41	2
"	"	4	Saburaud Agar	100	N 0291	06.05.2006	14:27	"	0,40	0,70	17	41	15
"	"	4	Violet Red Agar	100	N 0292	06.05.2006	14:30	"	0,40	0,70	17	41	1
İSKİ Tuzla Biol. WWTP	Grit Chamber	5	Plate Count Agar	100	N 0293	06.05.2006	14:39	Part. Cloudy	0,30	0,40	17	41	1100
"	"	5	Endo Agar	100	N 0294	06.05.2006	14:42	"	0,30	0,40	17	41	1200
"	"	5	Saburaud Agar	100	N 0295	06.05.2006	14:46	"	0,30	0,40	17	41	180
"	"	5	Violet Red Agar	100	N 0296	06.05.2006	14:49	"	0,30	0,40	17	41	170
İSKİ Tuzla Biol. WWTP	Fine Screen	10	Plate Count Agar	100	N 0297	06.05.2006	14:52	Part. Cloudy	NA	NA	17	45	320
"	"	10	Endo Agar	100	N 0298	06.05.2006	14:56	"	NA	NA	17	45	210

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	10	Saburaud Agar	100	N 0299	06.05.2006	14:59	"	NA	NA	17	45	180
"	"	10	Violet Red Agar	100	N 0300	06.05.2006	15:02	"	NA	NA	17	45	27
İSKİ Tuzla Biol. WWTP	Coarse Screen	6	Plate Count Agar	100	N 0301	06.05.2006	15:05	Part. Cloudy	0,30	0,40	17	40	24
"	"	6	Endo Agar	100	N 0302	06.05.2006	15:08	"	0,30	0,40	17	40	11
"	"	6	Saburaud Agar	100	N 0303	06.05.2006	15:11	"	0,30	0,40	17	40	29
"	"	6	Violet Red Agar	100	N 0304	06.05.2006	15:14	"	0,30	0,40	17	40	2
İSKİ Tuzla Biol. WWTP	Sludge Dewatering	7	Plate Count Agar	100	N 0305	06.05.2006	15:21	Part. Cloudy	0,20	0,30	17	44	9
"	"	7	Endo Agar	100	N 0306	06.05.2006	15:24	"	0,20	0,30	17	44	6
"	"	7	Saburaud Agar	100	N 0307	06.05.2006	15:27	"	0,20	0,30	17	44	1
"	"	7	Violet Red Agar	100	N 0308	06.05.2006	15:30	"	0,20	0,30	17	44	1
İSKİ Tuzla Biol. WWTP	DAF	8	Plate Count Agar	100	N 0309	06.05.2006	15:37	Part. Cloudy	0,40	0,60	16	40	6
"	"	8	Endo Agar	100	N 0310	06.05.2006	15:40	"	0,40	0,60	16	40	2
"	"	8	Saburaud Agar	100	N 0311	06.05.2006	15:43	"	0,40	0,60	16	40	3

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	8	Violet Red Agar	100	N 0312	06.05.2006	15:46	"	0,40	0,60	16	40	0
İSKİ Tuzla Biol. WWTP	Security Building	9	Plate Count Agar	100	N 0313	06.05.2006	15:51	Part. Cloudy	0,40	0,40	16	40	22
"	"	9	Endo Agar	100	N 0314	06.05.2006	15:54	"	0,40	0,40	16	40	0
"	"	9	Saburaud Agar	100	N 0315	06.05.2006	15:57	"	0,40	0,40	16	40	35
"	"	9	Violet Red Agar	100	N 0316	06.05.2006	16:00	"	0,40	0,40	16	40	0
Tuzla	1 km away		Plate Count Agar	100	N 0317	06.05.2006	16:16	Part. Cloudy	0,30	0,50	16	40	42
"	"		Endo Agar	100	N 0318	06.05.2006	16:19	"	0,30	0,50	16	40	1
"	"		Saburaud Agar	100	N 0319	06.05.2006	16:22	"	0,30	0,50	16	40	3
"	"		Violet Red Agar	100	N 0320	06.05.2006	16:25	"	0,30	0,50	16	40	0
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber	1	Plate Count Agar	100	N 0321	07.05.2006	10:54	Part. Cloudy	0,60	0,70	15	45	508
"	"	1	Endo Agar	100	N 0322	07.05.2006	11:05	"	0,60	0,70	15	45	206
"	"	1	Saburaud Agar	100	N 0323	07.05.2006	11:08	"	0,60	0,70	15	45	90
"	"	1	Violet Red Agar	100	N 0324	07.05.2006	11:12	"	0,60	0,70	15	45	50

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber	1	Plate Count Agar	100	N 0325	07.05.2006	11:23	Part. Cloudy	0,60	0,70	15	45	1000
"	"	1	Endo Agar	100	N 0326	07.05.2006	11:26	"	0,60	0,70	15	45	220
"	"	1	Saburaud Agar	100	N 0327	07.05.2006	11:29	"	0,60	0,70	15	45	140
"	"	1	Violet Red Agar	100	N 0328	07.05.2006	11:34	"	0,60	0,70	15	45	15
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber (10 m away)	10	Plate Count Agar	100	N 0329	07.05.2006	11:38	Part. Cloudy	0,60	0,70	17	45	35
"	"	10	Endo Agar	100	N 0330	07.05.2006	11:45	"	0,60	0,70	17	45	32
"	"	10	Saburaud Agar	100	N 0331	07.05.2006	11:48	"	0,60	0,70	17	45	2
"	"	10	Violet Red Agar	100	N 0332	07.05.2006	11:50	"	0,60	0,70	17	45	0
İSKİ Paşaköy Biol. WWTP	Fine Screen Grit Chamber (10 m away)	10	Plate Count Agar	100	N 0333	07.05.2006	11:53	Part. Cloudy	0,60	0,70	17	45	90
"	"	10	Endo Agar	100	N 0334	07.05.2006	11:56	"	0,60	0,70	17	45	22
"	"	10	Saburaud Agar	100	N 0335	07.05.2006	11:58	"	0,60	0,70	17	45	15
"	"	10	Violet Red Agar	100	N 0336	07.05.2006	12:01	"	0,60	0,70	17	45	8
İSKİ Paşaköy Biol. WWTP	Sludge Tank	2	Plate Count Agar	100	N 0337	07.05.2006	12:13	Part. Cloudy	0,30	0,60	17	42	5

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	2	Endo Agar	100	N 0338	07.05.2006	12:16	"	0,30	0,60	17	42	0
"	"	2	Saburaud Agar	100	N 0339	07.05.2006	12:19	"	0,30	0,60	17	42	0
"	"	2	Violet Red Agar	100	N 0340	07.05.2006	12:23	"	0,30	0,60	17	42	0
İSKİ Paşaköy Biol. WWTP	P Removal Tank	3	Plate Count Agar	100	N 0341	07.05.2006	12:32	Part. Cloudy	0,50	1,10	17	42	3
"	"	3	Endo Agar	100	N 0342	07.05.2006	12:35	"	0,50	1,10	17	42	0
"	"	3	Saburaud Agar	100	N 0343	07.05.2006	12:38	"	0,50	1,10	17	42	0
"	"	3	Violet Red Agar	100	N 0344	07.05.2006	12:43	"	0,50	1,10	17	42	0
İSKİ Paşaköy Biol. WWTP	Aeration (Influent)	4	Plate Count Agar	100	N 0345	07.05.2006	12:55	Part. Cloudy	0,50	0,90	17	42	4
"	"	4	Endo Agar	100	N 0346	07.05.2006	12:59	"	0,50	0,90	17	42	0
"	"	4	Saburaud Agar	100	N 0347	07.05.2006	13:04	"	0,50	0,90	17	42	0
"	"	4	Violet Red Agar	100	N 0348	07.05.2006	13:07	"	0,50	0,90	17	42	0
İSKİ Paşaköy Biol. WWTP	Aeration (Effluent)	5	Plate Count Agar	100	N 0349	07.05.2006	13:11	Part. Cloudy	0,50	0,90	17	42	110
"	"	5	Endo Agar	100	N 0350	07.05.2006	13:16	"	0,50	0,90	17	42	28

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	5	Saburaud Agar	100	N 0351	07.05.2006	13:19	"	0,50	0,90	17	42	7
"	"	5	Violet Red Agar	100	N 0352	07.05.2006	13:23	"	0,50	0,90	17	42	0
İSKİ Paşaköy Biol. WWTP	Pumping Station	6	Plate Count Agar	100	N 0353	07.05.2006	13:32	Part. Cloudy	0,50	0,90	17	42	90
"	"	6	Endo Agar	100	N 0354	07.05.2006	13:36	"	0,50	0,90	17	42	17
"	"	6	Saburaud Agar	100	N 0355	07.05.2006	13:45	"	0,50	0,90	17	42	9
"	"	6	Violet Red Agar	100	N 0356	07.05.2006	13:48	"	0,50	0,90	17	42	0
İSKİ Paşaköy Biol. WWTP	Final Clarifier	7	Plate Count Agar	100	N 0357	07.05.2006	14:01	Part. Cloudy	0,50	0,90	17	42	0
"	"	7	Endo Agar	100	N 0358	07.05.2006	14:05	"	0,50	0,90	17	42	1
"	"	7	Saburaud Agar	100	N 0359	07.05.2006	14:09	"	0,50	0,90	17	42	3
"	"	7	Violet Red Agar	100	N 0360	07.05.2006	14:12	"	0,50	0,90	17	42	0
İSKİ Paşaköy Biol. WWTP	Office Building	8	Plate Count Agar	100	N 0361	07.05.2006	14:24	Part. Cloudy	0,50	1,00	17	41	9
"	"	8	Endo Agar	100	N 0362	07.05.2006	14:28	"	0,50	1,00	17	41	0
"	"	8	Saburaud Agar	100	N 0363	07.05.2006	14:31	"	0,50	1,00	17	41	2

Plant Name	Sampling Point	Nr	Agar	Sampling volume (lt)	Sample Nr	Date	Time	Weather	Wind Velocity min (m/sn)	Wind Velocity max (m/sn)	Temp. (°C)	Humd. (%)	Result (CFU)
"	"	8	Violet Red Agar	100	N 0364	07.05.2006	14:34	“	0,50	1,00	17	41	3
Paşaköy	1 km away		Plate Count Agar	100	N 0365	07.05.2006	14:55	Part. Cloudy	0,40	0,80	17	42	12
"	"		Endo Agar	100	N 0366	07.05.2006	15:04	“	0,40	0,80	17	42	0
"	"		Saburaud Agar	100	N 0367	07.05.2006	15:09	“	0,40	0,80	17	42	2
"	"		Violet Red Agar	100	N 0368	07.05.2006	15:16	“	0,40	0,80	17	42	0

CURRICULUM VITAE

Ayca ÇAKIR was born in Trabzon, Turkey, 1979. She grauated from Bakırköy Sabri Çalışkan High School. She enrolled to the Yıldız Technical University, Civil Engineering Faculty, Environmental Engineering Department in 1997. After a year of English Preparation courses, she graduated from the department in 2003 and started to M.Sc degree education in the İstanbul Technical University Environmental Biotechnology master program. She is an Environmental, Health and Safety Supervisor in Bıçakcılar Healthcare Products since 2003.