***Chapter One***

***Introduction***

**1.1 Introduction**

Rapid population growth and urbanization are causing rapid changes in civilizations demands and issues of living. One of the most important issue and requirement is the significant increase in potable water consumption. Humanity is facing a crucial problem in supplying water for the growing societies with the fact of water resources limitation and water environmental pollution. With these criteria's, appropriate solutions such as wastewater recycling and reuse had been raised and polarized global interests (Hemmings *et. al*., 1983).

Biological wastewater treatment, as its name suggested, occur entirely by biological mechanisms. These biological processes reproduce, in a certain way, the natural processes that take place in water body after a waste water discharge. In a water body, organic matter is converted into inert products by purely natural mechanisms, characterizing the self-purification phenomenon. In a waste water treatment plant, the same basic phenomena occur, but the difference is that there is an introduction of technology. This technology has the objective of making the purification process develop under controlled conditions (Von Sperling, 2007).

A sewer system can serve not only as transportation network for wastewater but also as a transformation reactor for municipal waste water as it contains significant amount of biomass in form of suspended bacteria or sewer wall biofilm (Shoji *et al*., 2015). Sewers have considerable potential for the removal of organic material and nutrients through the physical, chemical and biological processes that take place

naturally within a sewer system. The impact of these processes on the chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrogen and phosphorus content of the wastewater can be significant (Warith *et al*., 1998). Microbial processes in wastewater of sewer systems proceed during transportation; these processes take place in the water phase, in the biofilms and in temporarily settled sewer sediments. Soluble as well as particulate wastewater compounds undergo transformation processes (Vollertsen *et al.*, 1999)

**1.2 Gravitational Sewer System**

A conventional gravity sewer system is used to collect wastewater from multiple sources and transfer it by gravity to a treatment plant or other authorized point of discharge. The sewer pipelines are designed so that the slope and size of the pipe is adequate to maintain flow without surcharging manholes or pressurizing the pipe. The collection sewer pipelines are typically eight-inch or larger in diameter. Pipes are installed with sufficient slope to keep the suspended solids moving though the system. If gravity flow is not possible throughout the system, lift stations are installed at lower elevations of the network in order to pump the sewage up to another gravity pipeline. Manholes are installed at regular intervals to provide maintenance access (Von Sperling, 2007).

The biofilm layer settled on the walls of sewer system pipes is a common formation in the natural environment. Biofilm can be well-defined as a natural accumulation of microorganisms on the solid body surface, algae that covering the surface of solid in the river water or the establishments of the biological sewage treatment plant is well example of natural biofilm. Environmental condition has a great influence on the

variation of particular species in biofilm composition in various WWTPs or rivers (Shoji et al., 2015).

High concentration pollutants can be characterized in the fresh sewage sanitation in a form of organic compounds with particles of various properties and dimensions. These pollutants enrich the environment with available nourishment substrates for both the biofilm layer and the suspended biomass. Biofilm in sewers is spatially strongly heterogeneous and consists of caverns, networks and pores filled with liquids or gases depending on real environmental conditions. Biofilm is a potently varied system and important in the biodegradation process of organic contaminates in sewage gravitational sewer system (Łagód *et al.*, 2010).

**1.3 Biological Degradation**

Biodegradation is the decay of substances via living biomass as bacteria, fungi, algae of other biological means. The term is frequently used in relation to biomedicine, [waste management](https://en.wikipedia.org/wiki/Waste_management), ecology, and the natural environment [bioremediation](https://en.wikipedia.org/wiki/Bioremediation). It is now commonly associated with environmentally-friendly products, capable of decomposing back into natural elements (Von Sperling, 2007).

Organic material presented in sewer system can undergoes significant degradation in the presence of micro organics in both aerobic and anaerobic conditions. Aerobic biological treatment consists of supplying oxygen to the biomass presented already in sewage water or to the activated sludge in bioreactors in order to maintain and grow microorganisms. Both the carbon-based pollutants and the nitrogen based pollutants are then degraded by the combined biological activities of heterotrophic and autotrophic bacteria (Henze *et al*., 2000).

In another hand, anaerobic digestion is a biological phenomenon that appears when oxygen and nitrate concentrations are very low in the system. Under specific temperature and for sufficient residence times, specialized micro-organisms become active. The organic nutrients present in the sewage are then used by these microorganisms which partially convert it into a mix of methane and carbon dioxide (Batstone *et al*., 2000).

**1.4 Research Originality and Impact**

As sewage water treatment have a crucial impact toward environmental and civilization planning and growth, many researches were conducted in this field. Many aspects related to wastewater treatment plants (Echeverria *et al*. 1992), sewer system water management (Nielsen *et al.*, 1992), anaerobic sewage treatment (Aiyuk *et al.*, 2006; Foresti *et al.*, 2006; Gomec, 2010; Chong *et al.*, 2012) were thoroughly investigated and studied.

In term of water scarcity, Iraq is a semi-arid country that disposing millions of litters of wastewater every day to rivers casing sever pollutions and damage to water streams in the environment. As a contribution in wastewater policy and planning, this study will reveal a new concept in the strategy of water resources management and can be further invested in the irrigation or other water utilities.

The current research will investigate the possibility of using wastewater network systems as aerobic biological treatment facility for partial sewage treatment. This aspect can lead to thorough understanding to the factors affecting organic wastes degradation in sewer by investigating the significant factors affecting the process, i.e.: temperature, retention time and the presence of activated sludge. A better

understanding of these processes in the sewer system to enhance partial removal of organic substrates is one of the aspirations of the current study. Investigating partial organic removal during transportation can help in reducing the high organic load on WWTP.

**1.5 Objectives of the Study**

This study investigates the possibility of using sewer systems for partial treatment of wastewater during transmission. The main goal of the study can be achieved by the following objectives:

1. Designing and conducting a pilot scale system to simulate real sewer system with some modification to enhance partial degradation.
2. Investigating the performance of the designed pilot system under continuous aeration in specific points to show the effect of aeration on organic degradation.
3. Operating and testing the system with the addition of activated sludge to investigate the effect of adding extra biomass to wastewater. Investigating the behavior of the system in terms of organic substances degradation in different ambient temperature to highlight the role of temperature in biomass activity.
4. Studying the kinetics of degradation by choosing the appropriate mathematical approach to estimate reaction kinetics factors.
5. Adopting a suitable technique to estimate the overall oxygen transfer rate during aeration process to show the significance of aeration method in delivering oxygen to microorganisms.

**1.6 Thesis Layout**

The scopes of the present work are demonstrated as follows:

* Chapter two represents complete literature reviews related to the research scopes including a revision of the previous researches and approaches related to the topic of the thesis.
* Chapter three deals with the experimental methodology and theoretical approaches used to estimate the research results.
* Chapter four demonstrates and discusses the results extracted from the experimental parts sand mathematical approaches used in the study.
* Chapter five introduces the complete conclusions for the results and practical recommendations for future work.