Natural Aeration with Artificial System to Raw Water for Water Supply Process of Rajabhat Mahasarakham University, Maha Sarakham Province

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Abstract:- This research aims to establish a gravity-based aeration system for raw water in the water supply process at Rajabhat Mahasarakham University. The objectives included evaluating the system's effectiveness for oxygen transfer and developing a suitable model for water supply applications. The study assessed various water quality parameters, including total suspended solids (TSS), biochemical oxygen demand (BOD5), and total coliform bacteria. In a series of six tests conducted at monthly intervals between 09:00 and 09:30 a.m., both inlet and outlet water were collected for a total of 12 samples. Results revealed that the gravity-based aeration system could reduce suspended solids by 54.87%. The average BOD5 of water at inlet and outlet was found to be 7.10 mg/L and 6.88 mg/L, respectively, indicating a 3.04% reduction in BOD5. Moreover, the gravity-based aeration system could reduce total coliform bacteria by 82.26%. To maximize the system's efficiency in eliminating total coliform bacteria, it is recommended to operate the system under optimal conditions and regularly clean the sediment tank when the system is shut down.

Keywords*: Natural Aeration, Raw water, Oxygen transfer, Gravity flow system, Water supply*

1. Introduction

Water is an essential element for all living organisms, and our planet's surface is predominantly covered by it, with around 97% of the total water found in oceans. The remaining 3% constitutes freshwater, and just about 1% of this freshwater is readily available for human consumption, primarily in the form of lakes, streams, and rivers [1] Mahasarakham, a province in central northeastern Thailand, has a variety of water resources, including rivers, water reservoirs, and numerous small water bodies. Among these water resources, the Huay Kha Khang Canal, stretching 47 kilometers, stands out as one of the most significant sources of freshwater. This canal flows through the Mahasarakham municipal area and Rajabhat Mahasarakham University, providing freshwater in these areas. The water from the Huay Kha Khang canal is pumped into the Nong Nok Ped reservoir, which serves multiple purposes, including water supply production and lawn irrigation at Rajabhat Mahasarakham University. Additionally, the Huay Kha Khang canal plays a vital role as a water source for various activities such as agriculture, aquaculture, and residential consumption.

In the past, freshwater resources were relatively unaffected by diverse pollutants, which could often be effectively treated by natural systems. This made it possible to utilize freshwater resources safely for human activities. However, the modern world presents new challenges as a result of the increasing world population. The current global population of 7.6 billion is projected to reach 8.6 billion by 2030 [2]. This population growth, coupled with economic development and urban expansion, has led to a significant increase in freshwater consumption. At present, freshwater is extensively used for agricultural irrigation as well as various municipal and industrial purposes [3]. Many freshwater resources also serve as sinks for untreated wastewater discharges containing various organic and inorganic pollutants. As a result, freshwater sources are now contaminated by waste from human activities, deteriorating water quality and affecting aquatic ecosystems, agriculture, industrial sectors, and the well-being of people living in these areas. [4] For instance, a striking illustration can be found in the water supply in the Bang Pa-In industrial estate, sourced from the Chao Praya River, which exhibits a total coliform count of approximately 10,500 CFU/100 mL.

The existence of decomposable organic substances leads to a decline in oxygen concentrations within lakes, natural water reservoirs, and rivers, culminating in unpleasant odors and the mortality of aquatic fauna. Additionally, various other organic compounds, including pesticides, detergents, fats, oils, greases, and solvents, produce detrimental effects, visual displeasure, and the potential for accumulation within the food chain. Consequently, it is imperative to manage water treatment in a scientifically valid manner [5]. A recent surge in research related to water treatment offers promise for mitigating the global impact of compromised water sources. Traditional approaches to water disinfection, purification, and desalination can effectively address a range of quality and supply issues. However, these treatment methods often rely on chemicals, substantial energy inputs, and complex operations, with a focus on large-scale systems. As a result, they demand significant investments in capital, engineering expertise, and infrastructure, limiting their applicability in many parts of the world. Even in highly industrialized nations, the costs and time required to develop cutting-edge conventional water and wastewater treatment facilities make it challenging to tackle all water-related issues comprehensively. Additionally, the intensive use of chemicals (such as ammonia, chlorine compounds, hydrochloric acid, sodium hydroxide, ozone, permanganate, alum and ferric salts, coagulants, filtration aids, antiscalants, corrosion control chemicals, ion exchange resins, and regenerants) and the resulting byproducts from treatment (such as sludge, brines, and toxic waste) can contribute to the contamination and salinization of freshwater sources. Furthermore, in many regions of the world, chemically intensive treatment methods are impractical due to the absence of suitable infrastructure [6].

In central Europe, a trend has emerged towards reducing the use of chemical treatments by adopting engineered natural systems for the production of drinking water. This shift is aimed at minimizing the presence of residual chemicals in distribution systems [7]. Fortunately, there is still significant untapped potential for science and technology to address environmental concerns and enhance efficiency. This is because current treatment methods are far from reaching the inherent limits prescribed by natural laws when it comes to tasks like separating compounds, deactivating or eliminating harmful pathogens and chemical agents, facilitating the movement of water molecules, and transporting ions against concentration gradients. It is expected that by focusing on the scientific aspects of interactions occurring at the interface between water constituents and the materials used in treatment processes, novel, sustainable, cost-effective, safe, and resilient methods can be developed and put into practice. These methods will serve the global population by expanding water supplies and ensuring water purification [6].

Aeration is a promising method for water treatment, particularly in ensuring the quality of raw water for supply. It is the process of introducing air into water, which serves multiple purposes in the water treatment process. Aeration systems facilitate the infusion of oxygen into water or liquid media through two primary methods: either by creating agitation at the liquid's surface using a mixer or turbine, or by introducing air via larger openings or porous materials. The descent of droplets and the ascent of sizable air bubbles lead to significant gas-liquid velocity disparities at their interfaces, categorizing them as interfaces in high-flow regimes. In contrast, smaller bubbles exhibit lower velocity gradients at their gas-liquid interfaces and are classified as interfaces in low-flow regimes [5]. The aeration system enhances the removal of impurities, such as dissolved gases, volatile organic compounds, and odorous substances, while also improving the overall water quality [8]. Aeration is vital in improving the taste and odor of water. It also assists in the removal of harmful substances, such as iron and manganese, which can be common in groundwater sources. The reduction of these impurities is essential for providing safe and aesthetically pleasing drinking water.

There are various methods and technologies used for aeration, including natural aeration systems (e.g., lakes, reservoirs, and rivers) as well as artificial systems like mechanical aerators and diffused aeration systems. Each type has its advantages and limitations. Natural systems, such as lagoons or open reservoirs, utilize environmental processes to aerate water. These systems are often cost-effective and sustainable, particularly when dealing with large volumes of water. Artificial aeration systems are engineered technologies and processes designed to enhance the contact area between air–water interface to enable a greater quantity of oxygen from the air to mix with the water through the agitation process [9-10]. The use of artificial aeration systems has been recognized for its ability to enhance biological processes and stimulate nitrification and denitrification mechanisms. Initially, the application of artificial aeration in constructed wetland systems was developed as a solution for treating challenging wastewater in cold climates. Although it requires additional energy input and associated costs, artificial aeration is considered to extend the operational lifespan of constructed wetlands [11] and still has advantages; for instance, in freshwater trout fish farms, it is commonly employed to prevent oxygen depletion in fish basins [12].

In a study by[12], the impact of artificial root zone aeration on the removal efficiency in horizontal subsurface flow-constructed wetlands (HSSFCWs) treating reconstituted trout farm effluent was investigated through mesocosm experiments. These experiments involved a combination of planted and unplanted beds, some with aeration and some without. Various water quality parameters, including chemical oxygen demand (COD), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), NH_4^+, and NO_3^-, were measured using standard methods [13]. The results showed that over 95% of TSS was effectively eliminated during the experiment, irrespective of the season, the presence of plants, or the use of aeration. These results outperformed the typical removal rates observed in full-scale HSSFCWs, which typically range from 75% to 85%, according to[14-15]. This performance also exceeded those observed in pilot-scale systems receiving a similar TSS loading of approximately 8 grams per square meter per day, as reported by [16]. The substantial retention of TSS is likely the result of the settled nature of the sludge utilized in the formation of the reconstituted effluent.

According to a study by [12], as anticipated for a pollutant primarily subject to physical removal processes, there was no noticeable distinction in TSS elimination between planted and unplanted conditions in both seasons. Nonetheless, there was a minor yet noteworthy enhancement in TSS removal in aerated mesocosms during both summer and winter ($p < 0.05$). It is plausible that artificial aeration lessened the accumulation of matter by promoting degradation. Furthermore, such a study indicated that COD removal rates exceeded 90% in all treatments except for unplanted, non-aerated mesocosms, which exhibited 88% removal. In summer, planted mesocosms showed a slight improvement in COD removal compared to unplanted ones, but artificial aeration had no significant effect, regardless of plant presence. During the winter season, the anticipated decrease in COD removal in non-aerated mesocosms was entirely offset by a substantial improvement in aerated mesocosms, both in scenarios with and without plantings. The introduction of additional oxygen in winter likely balanced out the reduction in removal rates attributed to lower temperatures and plant dormancy. It is important to note that factors enhancing the availability of electron acceptors or the oxidation status in the root zone can be just as critical as temperature in ensuring the removal of organic matter, as suggested by [12, 17], also demonstrated that artificial aeration had a positive impact on TKN removal during both summer and winter for unplanted units, but it did not entirely compensate for the absence of plants. This implies that the role of macrophytes extends beyond simply providing oxygen in the rhizosphere. In planted units, artificial aeration also enhanced TKN removal, albeit to a lesser extent compared to unplanted units.

As discussed above, natural aeration is a promising method in enhancing the quality of raw water. Therefore, the efficacy of natural aeration systems in improving water quality should be explored in the context of Rajabhat Mahasarakham University's water supply. However, it is essential to consider local factors and challenges in implementing aeration systems, including the climate, water source characteristics, and the energy required for operation. These considerations will play a crucial role in determining the most suitable aeration system for Rajabhat Mahasarakham University. Hence, this research investigates the establishment of natural aeration with an artificial system for the raw water supply process at Rajabhat Mahasarakham University. The study centers on aerating water sourced from Huay Kha Khang, which is pumped to the Nong Nok Ped reservoir using the existing pumping station. The efficiency of this new aeration system was compared to the previous technique, with a focus on changes in water characteristics. The system's performance was evaluated based on various water parameters, including TSS, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), and total coliform bacteria. This research would serve as a demonstration site for natural aeration with an artificial system, paving the way for further investigations. This initiative aligns with the overarching mission of sustainable development in the arena of water treatment and supply.

2. Objectives

The objectives included evaluating the system's effectiveness for oxygen transfer and developing a suitable model for water supply applications

3. Methods

The study of Aeration with Natural Artificial System to Raw Water for Water Supply Process was conducted in Rajabhat MahaSarakham University MahaSarakham Province. The research parameter data, namely dissolved oxygen (DO), suspended solids (SS), biological oxygen demand (BOD5), and total coliform bacteria were collected from the performing of the Natural Artificial System to Raw Water for Water Supply Process.

1. Data collection

In this research, the water samples were collected at two different points, namely,i) at the inlet pumping station to Nong Nok Ped swamp, and ii) at the outlet point of the Aeration with Natural Artificial System.This research was conducted in six months and the water samples were collected once a month and two sample each time. So, the total water samples were 12 samples. These water samples were analyzed by four water parameters, namely suspended solids (SS: mg/L), dissolved oxygen (DO: mg/L), biological oxygen demand (BOD: mg/L), and total coliform bacteria (MPN/100ml).

2. Research Instruments and System Design

The Aeration with Natural Artificial System was built by the roadside which located in between the Nong Nok Pedreservoir and the Huay Kha Khang pumping station. The system was designed and constructed by improving the existing system for energy saving. The schematic diagram of the Aeration with Natural Artificial System is illustrated in figures 3.1 and 3.2.

The advantages of using and improving the existing system to be the Aeration with Natural Artificial System are as follows.

1. Since the system was designed and constructed at the pumping station. The existing pump was applied for the Aeration with Natural Artificial System. There was unnecessary to install a new pump system. Therefore, it could save the cost and energy consumption.
2. The system was placed at the highest point of the water outlet. The water overflows and falls like a natural artificial waterfall.
3. The water discharges from the outlet pipe to the two holding ponds which act as the clarifier.
4. Adding oxygen to the water of this system is performed by a natural process. The water overflows from the 1.5 meters height of the ponds and it becomes thin layer flow. The thin layer water allows oxygen the be more dissolved.
5. The thin layer of water splashes when it reaches the concrete floor and it becomes droplets that can be more exposed to the air again.
6. After the water reached the concrete floor, water spread out on the wide concrete floor as a thin film. Consequently, water can be more exposed to air. Furthermore, the bacteria and pathogen can be reduced by the sunlight as well.
7. The water continuously flows through the concrete floor to the eight steps of the concrete cascade in which air-water mixture takes place.
8. The final two ponds after the eight cascades were designed to be a precipitation pond which can improve more efficiency of the system.
9. At the end part of the system, the 4.2 meters long of the concrete floor was constructed in order to spread the water to a thin film before it goes to the Nong Nok Pedreservoir.

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3. System test

The Aeration with Natural Artificial System was tested by discharging the raw water that was pumped from theHuay Kha Khang canal to the first and second pond, respectively. Then the water was overflown from those two ponds to the other five subsequent ponds. The flow characteristic of water was observedin order to improve the system.

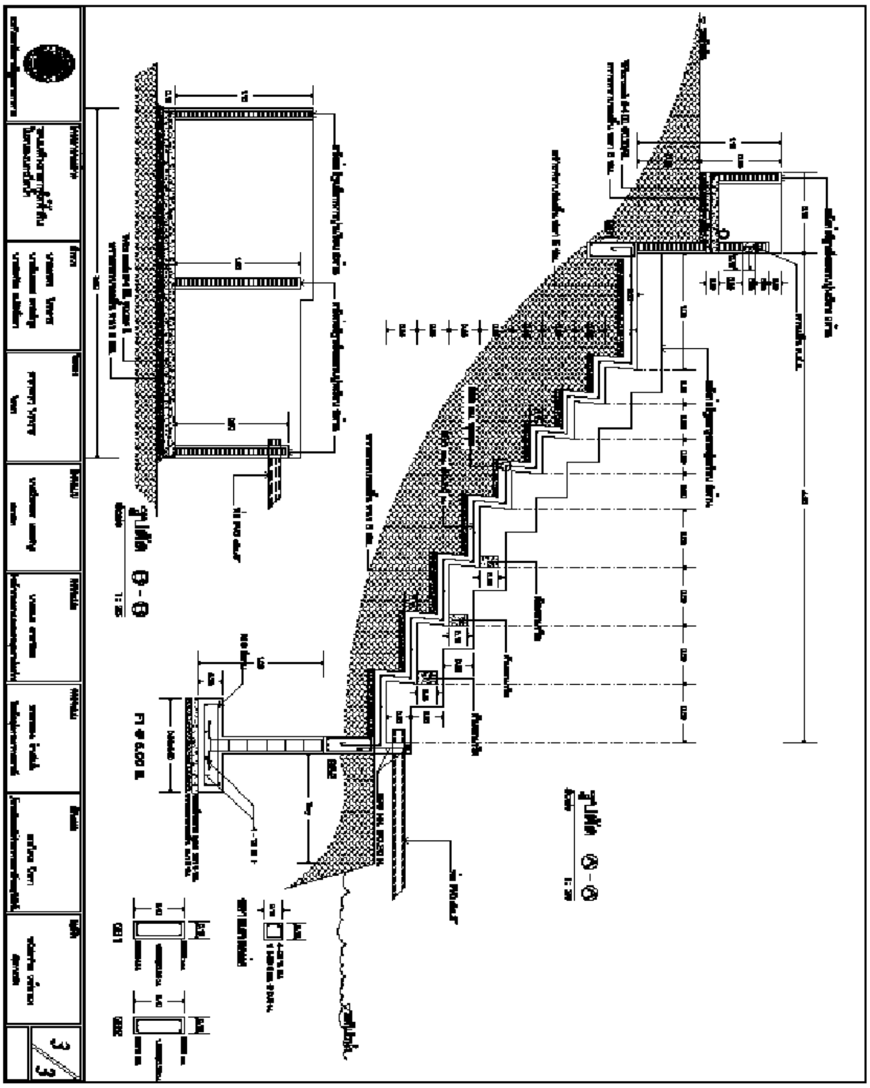


Fig 1: The schematic diagram of the Aeration with Natural Artificial System

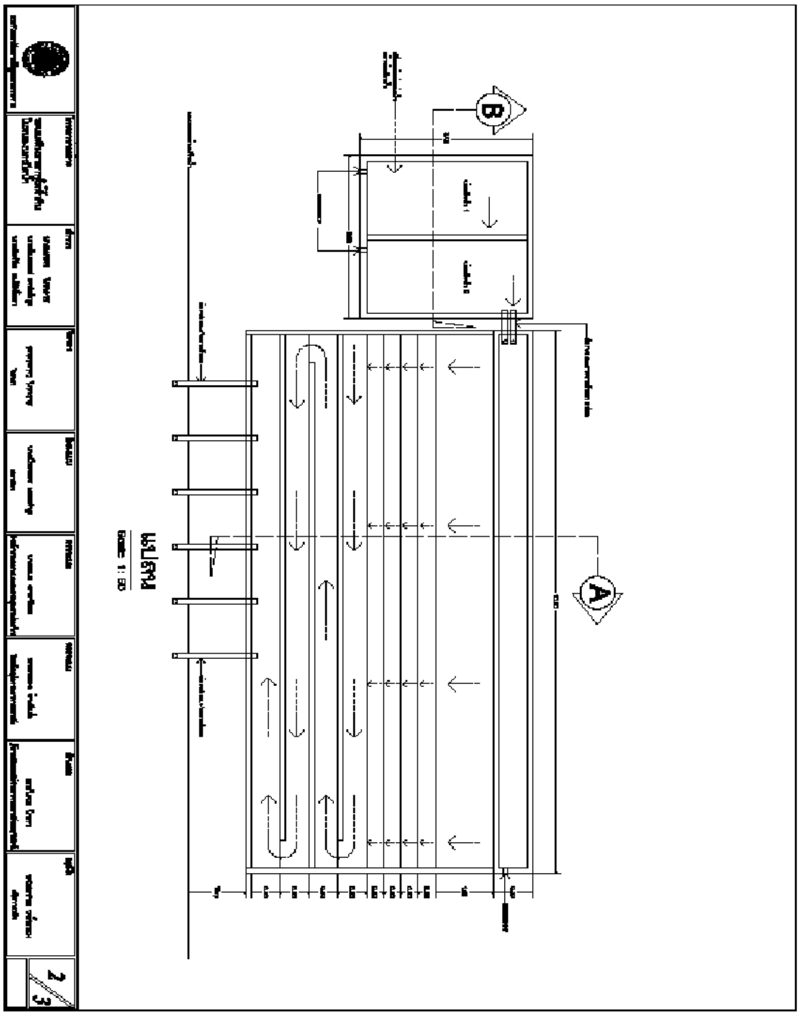


Fig 2: The schematic diagram of the Aeration with Natural Artificial System

4. Data analysis

4.1 The water samples from inlet and outlet point were analyzed by the physical, chemical and biological characteristic parameters including suspended solids (SS), dissolved oxygen (DO: mg/L), biological oxygen demand (BOD: mg/L), and total coliform bacteria(MPN/100ml). Parameters analyzed including the information on methods and measurement equipment are summarized in Table 1.

4.2 All laboratory analytical results of water samples at the inlet and outlet points were compared.

Table 1: Parameters analyzed in six months experiment, including the information on methods and measurement equipment.

Parameter	Measurement equipment and method
DO (mg/L)	DO meter
SS (mg/L)	Gravimetric analysis, evaporated and dried at 103-105°C
BOD_5 (mg/L)	BOD dilution method.

Total coliform bacteria (MPN/100ml)	Water samples were diluted. Then, bacteria were collected by membrane filtration technique onto the Cellulose Nitrate Membrane, 0.45µm diameter 0.47 mm. The Cultivated on Chromocult Coliform Agar (Merck Microbiology) and bacteria colony forming units counted and calculated. The experiment was three times repeated.

5. Statistical analysis

The obtained data from the study site and laboratory results were analyzed by statistical methods as follows.

Suspended solids (SS: mg/L), dissolved oxygen (DO: mg/L), biological oxygen demand (BOD: mg/L), and total coliform bacteria (MPN/100ml) were averaged compared the difference between inlet and outlet water. The efficiency of the Aeration with Natural Artificial System was determined by the efficiency equation as below.

$$1. \qquad (E) = \frac{A_{in} - A_{out}}{A_{in}} \times 100$$

Where; E = System efficiency
A in = Inlet water characteristic (water quality parameters)
A out = Outlet water characteristic (water quality parameters)

The system effective results were analyzed and determined that Natural Artificial System has the best efficiency of canal water quality improvement in which parameters.

4. Results

Aeration with Natural Artificial System to Raw Water for Water Supply was conducted by RajabhatMahaSarakham University, MahaSarakham province. The system is located at the Huay Kha Khang pumping station which pumps the water to the Nong Nok Ped reservoir. The water samples were collected from the inlet and outlet flow aeration with the natural artificial system. The samples were examined in a laboratory as the following parameters.

4.1 The results of Dissolved Oxygen (DO) from inlet and outlet flow (mg/L)
4.2 The results ofSuspended Solids (SS) from inlet and outlet flow (mg/L)
4.3 The results of Biological Oxygen Demand (BOD5) from inlet and outlet flow (mg/L)
4.4 The results of Total Coliform Bacteria from inlet and outlet flow (MPN/100ml)

1. The results of Dissolved Oxygen (DO) from inlet and outlet flow

The results from Aeration with Natural Artificial System experimented 6 times of collection. All data were collected to find out the efficiency of the system.

Table 2 Dissolved Oxygen from inlet and outlet flow (mg/L).

Experiment	**Dissolved oxygen (DO) (mg/L)**		**Difference(mg/L)**	**Efficiency (%)**
	Inlet flow	**Outlet flow**		
1	3.64	6.62	2.98	81.868
2	3.97	6.64	2.67	67.254
3	4.11	6.58	2.47	60.097
4	3.98	6.7	2.72	68.341
5	3.92	6.63	2.71	69.132
6	4.29	6.61	2.32	54.079

Average	3.985	6.63	2.645	66.795

From the table 2, the graph is shown in the fig 3

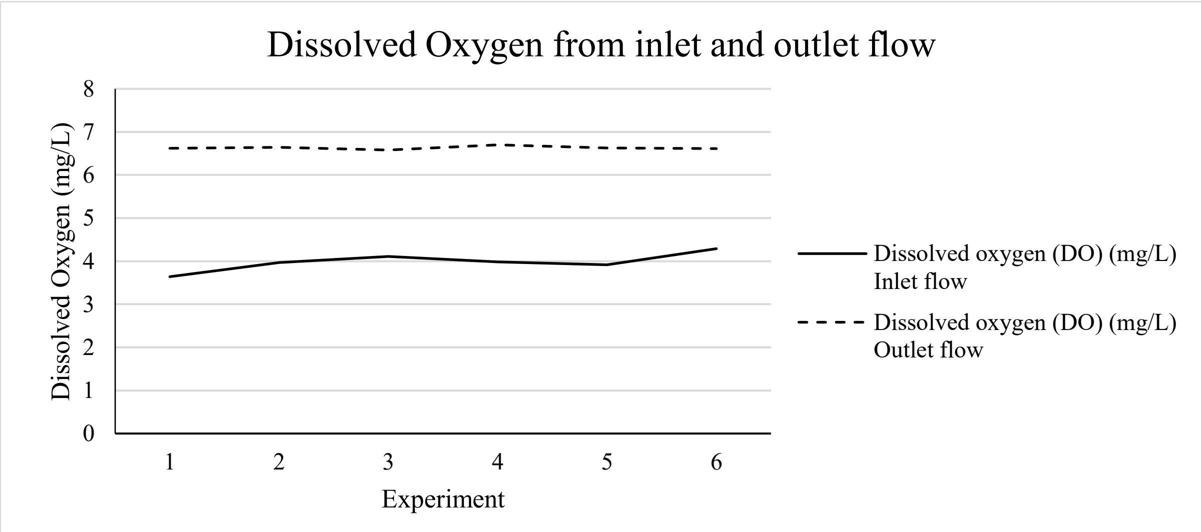


Fig 3: Dissolved Oxygen from inlet and outlet flow

2. The results ofSuspended Solids (SS) from inlet and outlet flow

The results of Suspended Solids were collected and experimented from the system for 6 times. The experiment was used to find the difference and efficiency of the Aeration with Natural Artificial system.

Table 3: Suspended Solids from inlet and outlet flow (mg/L).

Experiment	**SuspendedSolids (SS) (mg/L)**		**Difference (mg/L)**	**Efficiency (%)**
	Inlet flow	**Outlet flow**		
1	786.66	63.33	723.33	91.95
2	760	83.33	676.67	89.04
3	930	666.66	263.34	28.32
4	873.33	86.66	786.67	90.08
5	406.66	273.33	133.33	32.79
6	940	213.33	726.67	77.31
Average	782.775	231.107	551.668	68.248

From the table 3, the graph is shown in fig 4

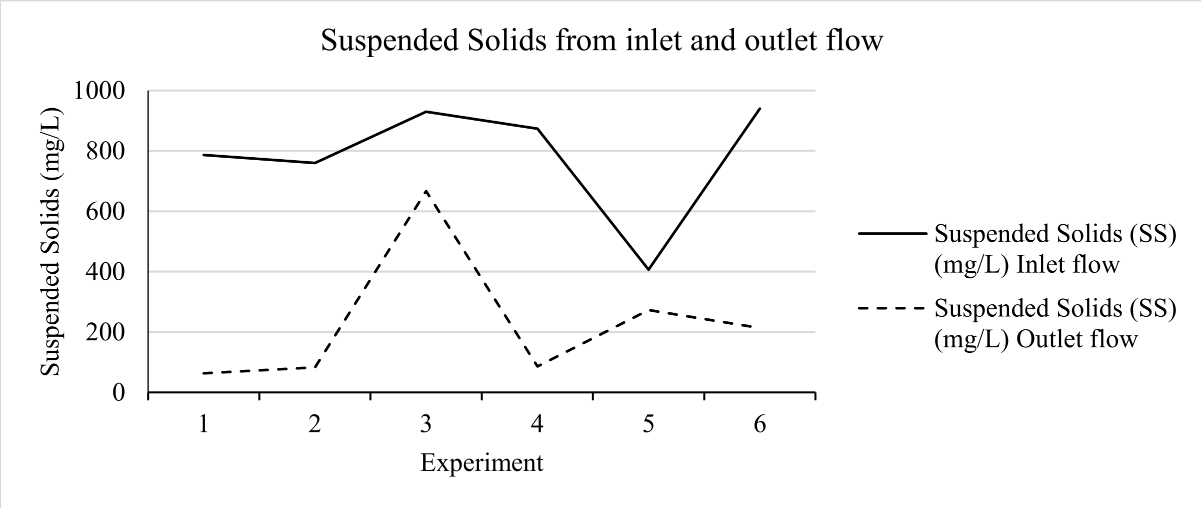


Fig 4: Suspended solids from inlet and outlet flow

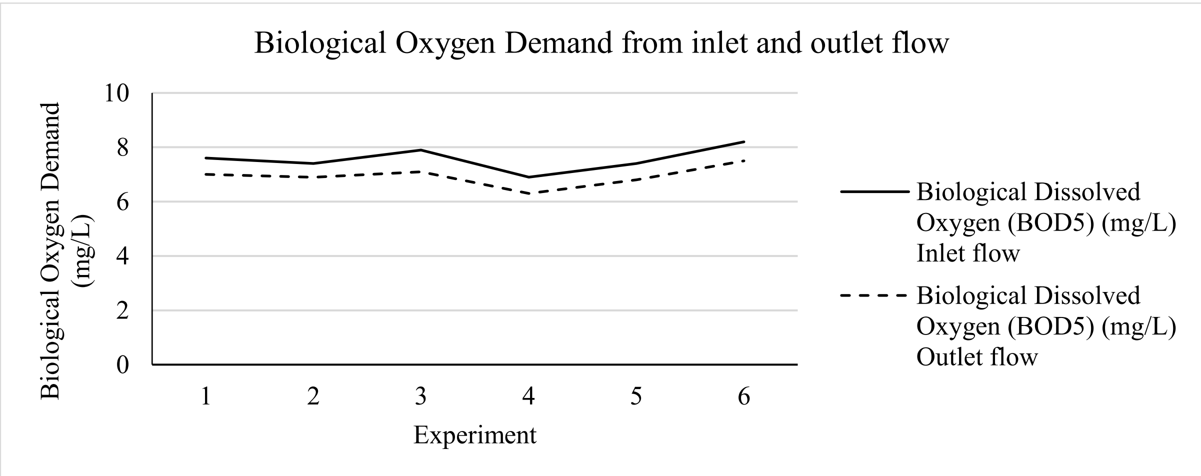
3. The results of Biological Oxygen Demand (BOD5) from inlet and outlet flow

There were 6 times of data collection to find out Biological Oxygen Demand from inlet and outlet flow. Data was collected and analyzed to find the difference and efficiency of Aeration with Natural Artificial system.

Table 4: Biological Oxygen Demand (BOD5) from inlet and outlet flow (mg/L).

Experiment	BiologicalOxygen Demand (BOD5) (mg/L)		Difference (mg/L)	Efficiency (%)
	Inlet flow	Outlet flow		
1	7.6	7	0.6	7.894
2	7.4	6.9	0.5	6.756
3	7.9	7.1	0.8	10.126
4	6.9	6.3	0.6	8.695
5	7.4	6.8	0.6	8.108
6	8.2	7.5	0.7	8.536
Average	7.566	6.933	0.633	8.352

From the table 4, the graph is shown in fig 5



Figu 5: Biological Oxygen Demand from inlet and outlet flow

4. The results of Total Coliform Bacteria from inlet and outlet flow

The results of the Total Coliform Bacteria study from Aeration with Natural Artificial system were 6 times of collection. All data was used to analyze the difference and efficiency of the system. The results are shown as follows.

Table 6: Total Coliform bacteria from inlet and outlet flow.

Experiment	Total Coliform Bacteria (MPN/100ml)		Difference (MPN/100ml))	Efficiency (%)
	Inlet flow	Outlet flow		
1	920	33	887	96.41
2	180	23	157	87.22
3	180	9	171	95
4	180	33	147	81.66
5	1,600	9	1591	99.43
6	220	110	110	50
Average	546.67	36.17	510.5	84.95

From the table 6,the graph is shown in fig 6

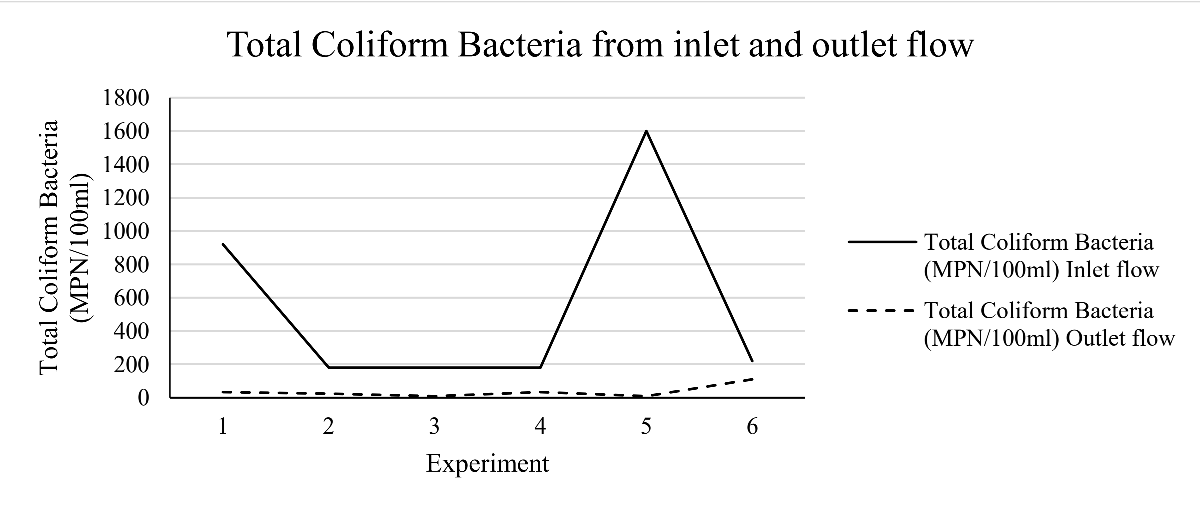


Fig 6: Total Coliform Bacteria from inlet and outlet flow

5. Discussion

1. Total Coliform Bacteria from inlet and outlet flow were 546.67 MPN/100ml and 36.17 MPN/100ml. The average difference between inlet and outlet flow was 510.50 MPN/100ml. The efficiency of the system was 99.43% for the highest average and 50% for the lowest average. If Total Coliform Bacteria from inlet flow compared with outlet flow, the results of the inlet and outlet flow can be clearly seen in figure 4.4.

From this research, the best efficiency of the system is to be used for reducing Total Coliform Bacteria in the water supply. As the system brings water and air in close contact in order to increase Dissolved Oxygen in water, it can significantly disinfect bacteria and pathogens in water. In water aeration, the air is filled into the water from Cascade Aerator which can cause the turbulent flow. The aeration allows water to contact more air along with the more cascade. Also, the system has a plate to spread processed water wider and become a thin layer. Sun rays can disinfect and reduce more bacteria and pathogens.

2. Suspended Solids (SS) from the inlet was around 782.775 mg/L and the outlet flow was around 231.107 mg/L. The difference between the inlet and outlet flow was 551.668 mg/. The efficiency of the system was 91.95% for the highest average and 28.32% for the lowest average. If Suspended Solids from inlet flow compared with outlet flow. The results can be seen in figure 4.2.

The efficiency of the Aeration with Natural Artificial System can reduce Suspended Solids in water supply significantly. Factors that lead to a reduction in Suspended Solids in water are as follows.

1. Pond design was divided into two ponds. When the first pond is full, water will flood into the second pond. Then water will flood from the second to precipitating ponds which are five ponds. If all five ponds are filled, water will flood out and become a waterfall. The retention time of water in the first 2 ponds and precipitation ponds is long enough to allow the large particles of suspended solids to settle.

2. Height of the ponds and height of precipitating ponds. It should be over 1 meter, it will be easier to precipitate because it makes large Suspended Solids precipitate easier and not flood out with water flow.

3. Width of the overflow weiror width of flooding water. Width is determined to be more than 10 meters. Since water becomes a thin layer, water will smoothly flood out. This causes the precipitation process in the ponds because Suspended Solids have retention time and fall to the bottom of the ponds.

3. Dissolved Oxygen (DO) from the inlet was around 3.985 mg/L and the outlet was around 6.630 mg/L. The difference between the inlet and outlet flow was 2.645 mg/L. The highest average efficiency of the system at 81.86%, while the lowest average efficiency was 54.079%. If Dissolved Oxygen from inlet flow compared with Dissolved Oxygen from outlet flow, the difference can be seen in figure 4.1.

From the experiments, the system can significantly increase Dissolved Oxygen in raw water source which is used for water supply. Factors that can cause a higher efficiency of the system are as follows.

1. The system makes water become a thin layer because of the overflow weir of the ponds which have 10 meters. When water falls from a height of 1.5 meters of the edge to the floor, water will become small droplets. Small droplets can be longer exposed to the oxygen in the air and increase Dissolved Oxygen in water.

2. There are eight sequentially steps which either allow step by step dissipation of overflow water, and it is called Cascade Aerator. The stepped transitions bring water and air in close contact, ensure a good air-water mixture. More steps of the system can increase higher aeration efficiency.

4. Biological Oxygen Demand (BOD5) from inlet and outlet flows were 7.566 mg/L and 6.933 mg/L. The average difference between inlet and outlet flow was 0.622 mg/L. The efficiency of the aeration system was 10.126% for the highest average and 6.756% for the lowest average. If Biological Oxygen Demand from inlet flow compared with Biological Oxygen Demand from outlet flow, the results can be seen in figure 4.3. Factors that can affect the efficiency of the system are as follows.

1. Dissolved Oxygen in water is significantly increased compared between the inlet and outlet flow. The more Dissolved Oxygen in water can decrease Biological Oxygen Demand (BOD5), and water becomes better quality.

2. Suspended Solids from outlet flow notably decreased from Suspended Solids from inlet flow. Suspended Solids in water demonstrate that it can reduce Biological Oxygen Demand to some extent.

6. Conclusion

This study successfully established a gravity-based aeration system for raw water within the water supply process at Rajabhat Mahasarakham University. The objectives were achieved by evaluating the system's effectiveness in terms of oxygen transfer and developing a practical model for water supply applications. The comprehensive assessment of various water quality parameters, including suspended solids, biochemical oxygen demand (BOD5), and total coliform bacteria, demonstrated the potential of the system to enhance water quality. The results indicated a substantial reduction in suspended solids by 54.87%, emphasizing the system's ability to clarify and improve the quality of raw water. The reduction in BOD5 by 3.04% also highlights its positive impact on organic matter removal, which is vital for maintaining water quality. Most notably, the system's efficiency in reducing total coliform bacteria by 82.26% underscores its significance in enhancing the safety of the water supply. To further optimize the performance of this gravity-based aeration system, it is essential to operate it under optimal conditions, ensuring its consistent efficiency in eliminating total coliform bacteria. Additionally, regular maintenance, particularly the cleaning of sediment tanks during system downtime, is recommended to sustain its effectiveness in water treatment and supply. This research offers valuable insights into the application of gravity-based aeration systems for water treatment, emphasizing their potential to improve water quality and safety in similar settings.

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