Aeration Bridge System in Huay Kha Khang Canel Rajabhat Maha Sarakham University, Maha Sarakham Province

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Abstract:- This research introduces the aeration bridge system implemented in the Huay Kha Khang Canal, Rajabhat Mahasarakham University, Maha Sarakham Province, which serves as a community demonstration site. Focusing on water quality enhancement, parameters such as temperature, pH, hardness, total dissolved solids, dissolved oxygen demand (DO), biochemical oxygen demand (BOD5), and total coliform bacteria were studied over 6 months. Results demonstrated improvements in temperature stability (25.48 - 26.12°C) and pH levels (7.21–7.35). The aeration bridge system exhibited notable efficiency in enhancing dissolved oxygen (47.55%) and reducing total coliform bacteria (32.292%). Significant reductions in water hardness (24.82%) and total dissolved solids (12.723%) were achieved. The system showcased a reduction in BOD5 of 11.94%. The study establishes the aeration bridge system as promising for polluted water bodies, emphasizing its impact on key water quality parameters. Further research and optimization are recommended for broader contaminant applications.

Keywords*: Aeration Bridge System, Huay Kha Khang Canel.*

1. Introduction

Water is a vital element for the existence of living organisms on Earth. More than 97% of Earth's water is seawater, while the remaining 3% is freshwater. Only about 1% of this freshwater is readily available for human consumption[1]. Historically, most freshwater resources were relatively unpolluted and safe for human activities. However, the increasing global population, economic growth, land-use changes, and urban expansion have led to a heightened demand for freshwater. This has resulted in a substantial increase in its use for agriculture, municipal, and industrial purposes[2]. Unfortunately, these changes have also brought about pollution in freshwater resources due to various contaminants from human activities, impacting the quality of freshwater. This, in turn, affects aquatic life, agriculture, industrial sectors, and the people living in these areas [3]. A notable example is the case of water supply in the Bang Pa-In industrial estate, sourced from the Chao Phraya River, exhibiting high levels of total coliform at about 10,500 CFU/100ml [4].

Maha Sarakham province boasts numerous freshwater resources, including rivers, water reservoirs, and smaller water bodies. The Huay Kha Khang canal, with a length of 47 km, traverses Mahasarakham municipal and Rajabhat Mahasarakham University. This canal serves multiple purposes, such as providing water for agriculture, aquaculture, and residential consumption. Unfortunately, it also acts as a receptacle for untreated and treated wastewater from residential areas, including the university, leading to contamination and potential impacts on water quality.

This study constructs an aeration bridge system in the Huay Kha Khang Canal at Rajabhat Mahasarakham University to assess the efficiency of the aeration system by comparing water characteristics before and after its installation. Key parameters considered for efficiency and performance included water temperature, water hardness, acidity-alkalinity, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD5), and total coliform bacteria. Additionally, this study aims to serve as a demonstration site for future research. The focus of this study is on aerating the water in the canal using the existing bridge as a support structure for the aeration system. This involves employing a pump and pipe system for water circulation and aeration. The novel innovation in this study lies in the potential to kill (or diminish) bacteria and pathogens by exposing them to air and sunlight, increase dissolved oxygen levels, and improve foul smells. Furthermore, this study contributes to the development of applicable technology that can be easily integrated into local communities, promoting sustainable development.

2. Methods

The water aeration system was built and performed the experiment in Huay Kha Khang canal which is located in Rajabhat Mahasarakham University in Maha Sarakham province, where treated wastewater from the university and untreated wastewater from surrounding community were discharged. This system was designed by using the Huay Kha Khang canal bridge as a supporting structure. Thus, this water aeration system is called the aeration bridge system.

2.1 System design

The aeration system was made and installed with the bridge onHuay Kha Khang canal. This system has two important parts, namely i) aeration systemand supporting structure, and ii) water pumpsystem. The design and detail of this system are described as following.

2.1.1 Aeration bridge system design

1. The cubic cage which has 1×1×1-meter size was assembled by using the metal square tubes (2 inches diameter). Then, one side of cubic cage was fixed with the concrete bridge on the canal.

2. Install metal square tubes (2 inches diameter) at about 50 cm. intervals along the length of the concrete bridgefor supporting six pieces of PVC pipe (4 inches diameter). All of metal tubes were protected by anticorrosion paint.

3. Drilling the water outlet orifices (10 mm diameter) on PVC pipes (3 inches diameter) at about 20 mm. intervals. Canal water was pumped and delivered through two inches pipe which was placed on the supporting structure at the bridge railing.Then, two inches pipe was connected with three inches drilled pipe, respectively.

2.1.2 Pump system installation

Electric water pump (3 HP, 2 inches inlet and outlet) was used in this system. Two inches pipe was installed with pump outlet then it was connected to three inches drilled pipes. Water of the canal was supplied to these 3 three inches drilled pipes which were installed by three level at about 0.5 meters intervalin vertical plane, then water was flown down from the first pipe (highest level) to the second pipe(middle level),third pipe (lowest level) and flown down to the canal, respectively.

2.2 Aeration bridge system test

The aeration bridge system was testedand operated at the study site. The flow pattern of water which was discharged through the orifices and flow down from pipes system to the canal was observed. The test resultswere used for the system improvements.

2.3 Data collection

In this study, water samples were collected at two different points namely, i) at the aeration bridge pumping point, and ii) the aeration bridge point where the water was flow down from the aeration bridge. At the second point, water samples were collected by the sampling container which was placed under the aeration bridge.This experiment was conducted in the period of six months and the water samples were collected twice a month. So, the total water samples were 12 samples. These water samples were analyzed by seven water parameters, namely temperature (degree Celsius), water acidity-alkalinity, water hardness (mg/L), Total dissolve solid (TDS: mg/L), dissolve 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.**

2.4 Data analysis

2.4.1 The physical, chemical and biological characteristic parameters including water hardness, total dissolve solid (TDS), dissolve oxygen (DO), biological oxygen demand (BOD), and total coliform bacteria were used for determining the characteristic of water in Huay Kha Khang canal. These parameters were analyzed in laboratory. Water temperature and acidity-alkalinity were measured at the study site.

2.4.2 All laboratory analytical results of water samples at pumping point and water which flown through the aeration bridge system were compared.

2.4.3 Statistical analysis

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

1. Water temperature and acid-alkalinity data were averaged and used for comparison between pumping point (inlet water) and the aeration bridge (outlet water).

2. Water hardness data, total dissolve solid, dissolve oxygen, biological oxygen demand, and total coliform bacteria were averaged and used for comparison between influent and effluent water. The efficacy of aeration bridge system was determined by the efficiency equation as below.

$$)E) = \frac{A\ in - A\ out}{A\ in} \times 100$$

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 this system has the best capable of canal water quality improvement in which parameters.

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

Parameter	Measurement equipment and method
pH	pH electrode
Temperature (°C)	Temperature displayed in the DO meter while measuring DO
DO (mg/L)	DO electrode
Water hardness	EDTA titrimetric method.
TDS (mg/L)	Gravimetric analysis, evaporated and dried at 180 ± 2 °C
BOD_5 (mg/L)	BOD dilution method.
Total coliform bacteria (CFU/ml.)	Bacteria were collected by membrane filtration technique onto 0.45μm diameter 0.47 mm. Cultivated on Chromocult Coliform Agar (Merck Microbiology) and bacteria colony forming units counted and calculated.

3. Results

The research of aeration bridge system in Huay Kha Khangcanal, Rajabhat MahaSarakham University, MahaSarakham province. The water samples were collected at the inlet and outlet point of the aeration bridge system. The water samples were collected from the canal which was analyzed in a laboratory. The results are as follows.

1. The result of water temperature (Degree Celsius) and acidity - alkalinity of collected water from inlet and outlet point of aeration bridge system.
2. The result of water hardness experiment from inlet and outlet point (mg/L).
3. The result of Total Dissolved Solids (TDS) from inlet and outlet point (mg/L).
4. The result of Dissolved Oxygen (DO) from inlet and outlet point (mg/L).
5. The result of Biological Oxygen Demand (BOD5) from inlet and outlet point of aeration bridge system(mg/L).
6. The result of Total Coliform Bacteria from the inlet and outlet point of aeration bridge system (MPN/100ml).

1.The result of water temperature (Degree Celsius) and pH balance of collected water from inlet and outlet point of aeration bridge system

The results of water temperature (°C) and water acidity - alkalinity of collected water from inlet and outlet point of aeration bridge system obtained from 6 times of experiment are shown in Table 2

Table 2 Temperature (Degree Celsius) and water acidity - alkalinity of collected water from inlet and outlet point.

Experiment	Water temperature (°C)			water acidity - alkalinity		
Sequence	**Inletpoint**	**Outletpoint**	**Difference**	**Inlet point**	**Outlet point**	**Difference**
1	24.4	23.8	0.6	7.7	7.5	0.2
2	25.3	24.7	0.6	7.4	7.3	0.1
3	27.6	26.8	0.8	7.3	7.2	0.1
4	28.2	27.5	0.7	7.3	7.2	0.1
5	26.4	25.9	0.5	7.2	7.1	0.1
6	24.8	24.2	0.6	7.2	7	0.2
Average	26.12	25.48	0.63	7.35	7.21	0.13

2 .The result of water hardness from inlet and outlet point

The results of water hardness experiment from the inlet and outlet point obtained from 6 times of experiment are shown in Table 3

Table 3 Water hardness experiment from the inlet ant outlet point from aeration bridge system (mg/L).

Experiment	Water hardness (mg/L)		Difference (mg/L)	Efficiency (%)
	Inlet point	Outlet point		
1	40	32	8	20
2	60	48	12	20
3	28	24	4	14.28
4	44	28	16	36.36
5	48	44	4	8.33
6	24	12	12	50
Average	40.67	31.33	9.33	24.82

From the table 3, the comparison of water hardness of water samples from inlet and outlet point was illustrated on the line graph, as in the figure 1.

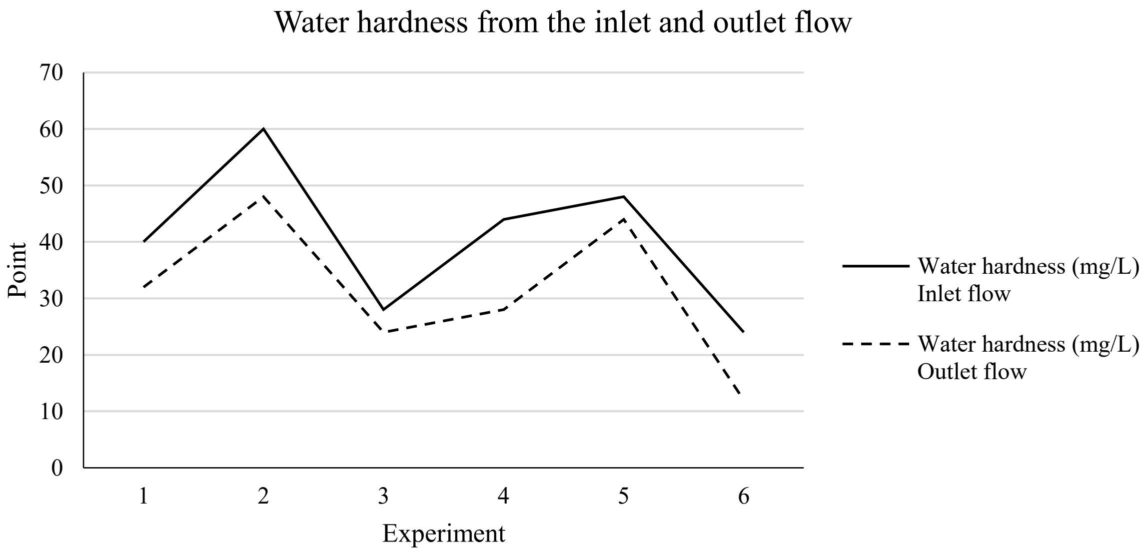

Figure 1 Water hardness from the inlet and outlet point (mg/L).

3. The result of Total Dissolved Solids (TDS) from inlet and outlet point of aeration bridge system

The result of Total Dissolved Solids (TDS) from the inlet and outlet point of aeration bridge system obtained from 6times of experiment are shown in Table 4.

Table 4 Total Dissolved Solids (TDS) from inlet and outlet point (mg/L).

Experiment	TotalDissolved Solids (mg/L)		Difference (mg/L)	Efficiency (%)
	Inlet point	Outlet point		
1	160	143	17	10.625
2	270	213	57	21.11
3	103	83	20	19.42
4	163	153	10	6.135
5	226	213	13	5.75
6	203	176	27	13.3
Average	187.5	163.5	24	12.723

From the table 4, the comparison of Total Dissolved Solids (TDS)of water samples from inlet and outlet point was illustrated on the line graph, as in the figure 2.

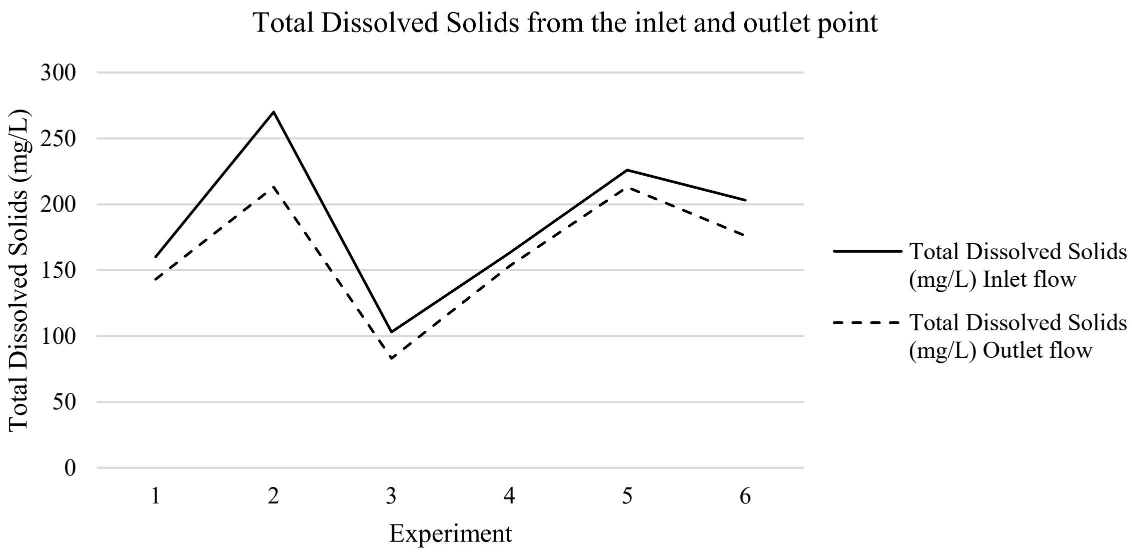

Figure 2 Total Dissolved Solids from inlet and outlet point (mg/L).

4. The result of Dissolved Oxygen (DO) from inlet and outlet point (mg/L)

The result of Dissolved Oxygen (DO) from inlet and outlet point of aeration bridge system. The obtained results show the different Dissolved Oxygen (DO) level, as shown in the Table 5.

Table 5 Dissolved Oxygen (DO) from inlet and outlet point of aeration bridge system.

Experiment	DissolvedOxygen (DO) (mg/L)		Difference (mg/L)	Efficiency (%)
	Inlet point	Outlet point		
1	5.85	7.24	1.39	23.76
2	3.95	6.09	2.14	54.18
3	5.93	7.55	1.62	27.32
4	4.81	7.86	3.05	63.4
5	4.33	6.71	2.38	54.96
6	4.7	7.6	2.9	61.7
Average	4.93	7.175	2.246	47.55

From the table 5, the comparison of Dissolved Oxygen (DO) of water samples from inlet and outlet point was illustrated on the line graph, as in the figure 3.

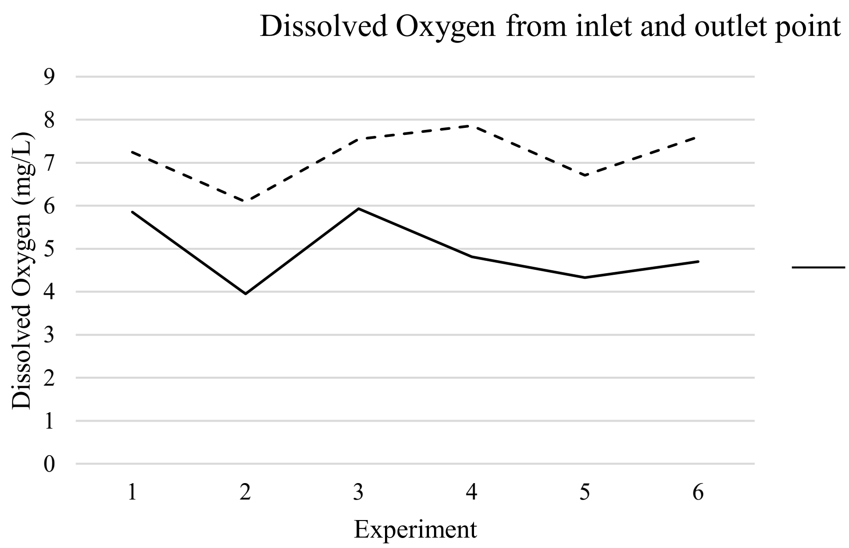

Figure 3 Dissolved Oxygen from inlet and outlet point (mg/L).

5. The result of Biological Oxygen Demand (BOD_5) from the inlet and outlet point of aeration bridge system(mg/L)

The result of Biological Oxygen Demand (BOD_5) from inlet and outlet of aeration bridge system. The 6 experiments were collected, and the results were compared in order to evaluate the efficiency of the system as shown in Table 6.

Table 6 Biological Oxygen Demand from inlet and outlet point.

Experiment	BiologicalOxygen Demand (mg/L)		Difference (mg/L)	Efficiency (%)
	Inlet point	Outlet point		
1	8.8	7.5	1.3	14.77
2	9.7	8.3	1.4	14.43
3	8.6	7.6	1	11.62
4	8.9	8.1	0.8	8.98
5	10	8.7	1.3	13
6	9	8.2	0.8	8.88
Average	9.16	8.06	1.1	11.94

From the table 6, the comparison of Biological Oxygen Demand (BOD_5)of water samples from inlet and outlet point was illustrated on the line graph, as in the figure 4.

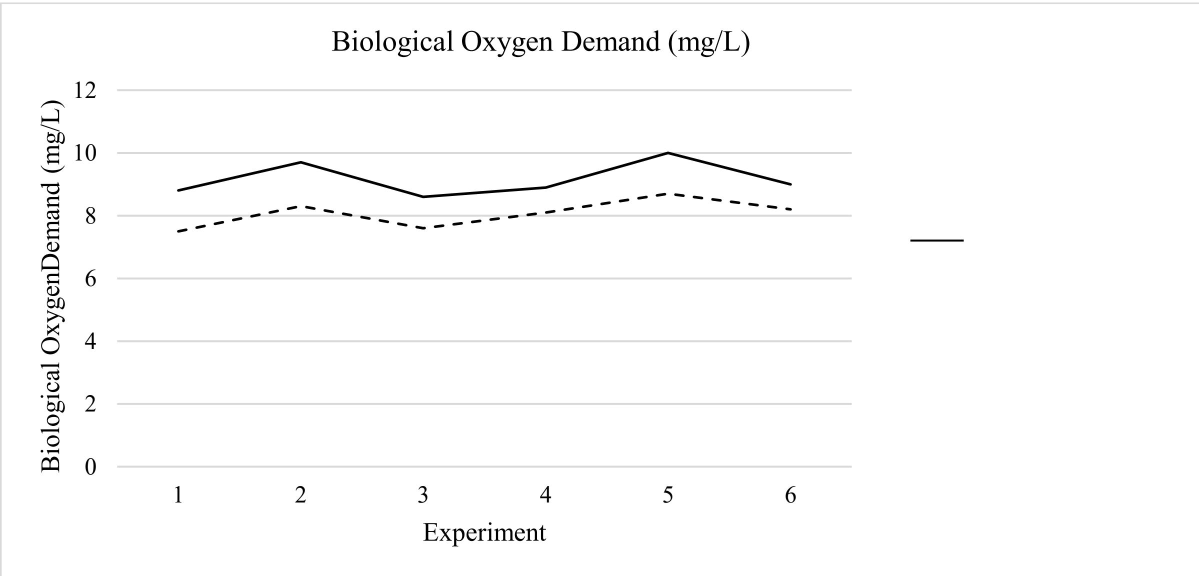

Figure 4 Biological Oxygen Demand from inlet and outlet point (mg/L).

6. The result of Total Coliform Bacteria from the inlet and outlet point (mg/L) of aeration bridge system (MPN/100ml)

The result of Total Coliform Bacteria from inlet and outlet point of aeration bridge system were obtained from 6 times of experiment and the efficiency of the system was analyzed, as shown in the Table 7.

Table 7 Total Coliform Bacteria from inlet and outlet point.

Experiment	Total Coliform Bacteria (MPN/100ml)		Difference (mg/L)	Efficiency (%)
	Inlet point	Outlet point		
1	1,600	920	680	42.5
2	2,400	2,400	0	0
3	1,600	920	680	42.5
4	1,600	540	1,060	66.25
5	2,400	2,400	0	0
6	1,600	920	680	42.5
Average	1,866.67	1,350.00	516.67	32.292

From the table 7, the comparison of Total Coliform Bacteriaof water samples from inlet and outlet point was illustrated on the line graph, as in the figure 5.

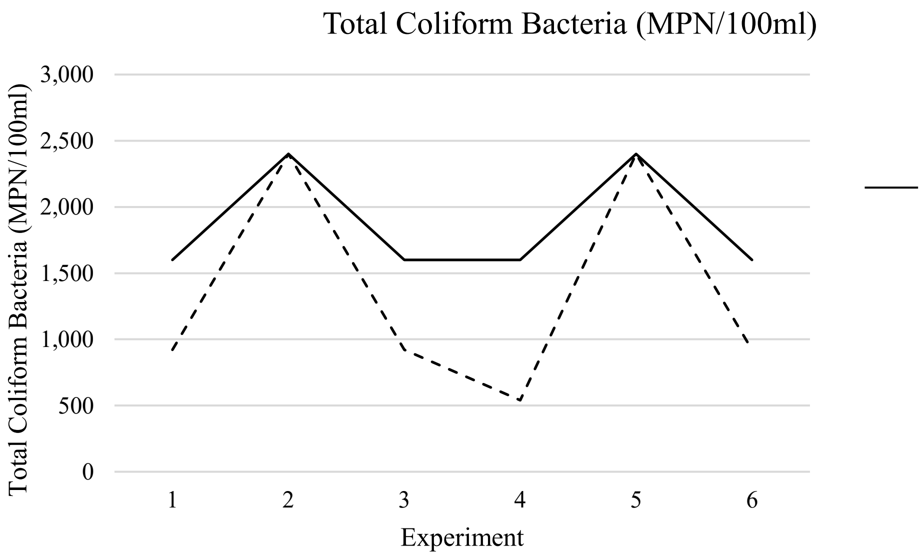

Figure 5 Total Coliform Bacteria from inlet and outlet point (mg/L).

4. Discussion

4.1 Dissolved Oxygen

The average dissolved oxygen values of inlet and outlet flow were 4.93 mg/L and 7.175 mg/L, respectively. The difference of the flow between inlet and outlet was 2.246 mg/L. The efficiency of the Aeration Bridge System was around 23.76% - 63.40%, and the overall efficiency of the system was 47.55%. The differences of Dissolved Oxygen (DO) from inlet and outlet flow are shown in the figure 4.3.

Factors that have effects on Dissolved Oxygen (DO) are as follows.

1. The Aeration Bridge System at Huay Kha Khang canal is 6 meters long, and the pipe was drilled 10 millimeters diameter along its length. At each hole, they are 20 millimeters interval along its length. The system

lets the water fall to plastic pipes below where water becomes droplets. Consequently, the oxygen can be easily dissolved which can be seen that the dissolved oxygen was increased significantly.

2. The water discharges from the holes and becomes small droplets when it hits the pipes, then it falls continuously to the second level of pipes which were located 50 centimeters under the first one. The water will fall through six different levels of pipes where the small water droplets can be longer exposed to the oxygen in the air. Therefore, the efficiency of water aeration was improved, and the efficiency of the system can be increased if there are more pipe levels.

4.2 Total Coliform Bacteria

The average values of total coliform bacteria at the inlet and outlet flow were 1866.7 MPN/100ml and 1,350.00 MPN/100ml, respectively. The difference of Total Coliform Bacteria between the inlet and outlet flow was 516.67 MPN/100ml. The efficiency of the system was around 0.00% – 66.25%. When Total Coliform Bacteria from inlet flow is compared with outlet flow, there was a significant result shown in figure 4.5

The Aeration Bridge System at Huay Kha Khang canal can remarkably reduce the amount of Total Coliform Bacteria in the canal water. Since the system allows water flow to absorb Oxygen in the air, it can sterilize the water or can disinfect and reduce bacteria in the water flow. The result can refer to amount of Oxygen, the number of pipes level and theturbulent flow have effects on the system efficiency.

However, Huay Kha Khang canal is one of the polluted water resources. It is categorized as class 3 and class 4 according to the surface water quality standard. So, the total coliform bacteria in the canal water is partially high. The Aeration Bridge System efficiency is around 32.292%. Therefore, the system can reduce Total Coliform Bacteria to some extent.

4.3 Water hardness

The average values of water hardness at the inlet and outlet flow were 40.67 mg/L and 31.33 mg/L, respectively. The difference is 9.33 mg/L, and the efficiency is in between 8.33% - 50.00%. There was a clear result of the system shown in figure 4.1

The Aeration Bridge System can lower water hardness 24.82%. As air is aerated in the canal and theaeration system efficiency is up to 47.55%, the water composition is changed then water hardness can be reduced by the system.

4.4 Total Dissolved Solids (TDS)

The average value of total dissolved solids at the inlet flow was 187.50mg/L, and the outlet was 163.50mg/L. The difference between inlet and outlet flow was 24.00mg/L, and the efficiency was between 5.750% - 21.110%. The figure 4.2 previously showed the Total Dissolved Solids from 6 experiments from the inlet and outlet flows.

The efficiency of a decrease in Total Dissolved Solids was 12.723% which is quite low if compared with other results. Because the purpose of the Aeration Bridge System is mainly used to increase Dissolved Oxygen in water, the system was not designed to store and separate dissolved solids or other substances from the water before releasing water to Huay Kha Khang canal. The system can barely separate dissolved solids than suspended solids in water.

4.5 The result of Biological Oxygen Demand (BOD5)

The average value of BOD at the inlet flow was 9.16 mg/L, and at the outlet flow was 8.06 mg/L. The difference between inlet and outlet flow was 1.10 mg/L, and theefficiency of the Aeration Bridge System was between 8.88% – 14.77%. The results of the experiments were before shown in figure 4.4.

Factors that can affect the different results of Biological Oxygen Demand from inlet and outlet flow are as follows.

1. The increase in Dissolved Oxygen from inlet flow compared with outlet flow. If quantities of Oxygen are high, it can reduce the dirtiness in water.

2. An obvious reduction in dissolved solids and water hardness is a possible factor. If water from inlet and outlet flows are compared, dirtiness and pollutants in water are evidently less; also, water is more clean and higher quality.

However, even though the Aeration Bridge System can reduce Biological Oxygen Demand (BOD5) in water, the values from inlet and outlet flows are still notably high. Since Huay Kha Khang canal is extremely dirty. It is also categorized as class 4 according to the standard quality of surface, and Biological Oxygen Demand (BOD5) can be reduced to some extent.

5. Conclusion

The implementation of the aeration bridge system in Huay Kha Khang Canal, Rajabhat Mahasarakham University, Maha Sarakham Province, proved to be effective in enhancing water quality. The comprehensive analysis of various parameters, including temperature, pH, hardness, total dissolved solids, dissolved oxygen, biochemical oxygen demand, and total coliform bacteria, provided valuable insights into the system's performance. According to the study, the aeration bridge system demonstrated notable success in improving dissolved oxygen levels, showcasing an overall efficiency of 47.55%. This significant increase in dissolved oxygen contributes to the system's ability to enhance water quality. Furthermore, the system exhibited substantial efficacy in reducing total coliform bacteria, achieving an efficiency of 32.292%, thereby addressing concerns related to microbial contamination. The study also revealed positive outcomes in terms of water hardness reduction, with an efficiency of 24.82%. However, it's important to note that the system's impact on total dissolved solids was relatively modest, achieving an efficiency of 12.723%. Additionally, while the system contributed to a reduction in BOD5, the values remained relatively high due to the polluted nature of Huay Kha Khang Canal. Moreover, the aeration bridge system's success in improving key aspects of water quality positions it as a promising technology for applications in polluted water bodies. However, further research and optimization should enhance its efficiency in dealing with additional contaminants.

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