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Study of Dissolved Oxygen (DO) Profile in Nalanda Lake, Sri Lanka

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Abstract- Nalanda Lake is (Long. 80º 37' 1.93" and Lat. 7º 40' 30.6") one of the ancient Lake in the Sri Lanka. It's fed by the Basin of Mahaweli River. This lake water is use for drinking, agriculture and human activities. Generally, in this lake observing the high amount of algae due to high nutrient content. Equally lake water had a less amount of Dissolved Oxygen (DO). The DO concentration is characterize of a lake healthiness. And also, the DO concentration responds to the Biological Oxygen Demand (BOD) load. Main Objective of this research was determined the DO concentration in selected Non-point source and developed the DO consumption model by using Mathematical Equation. Five different sample location points were selected. DO and BOD variation was studied during four weeks. Totally 20 samples were analyzed. DO was measured by DO meter (HACH Sension6), BOD was measured by the Winkler method. DO consumption was measured using Streeter-Phelps equation. According to investigated data DO vary (8.31±0.76 – 10.02±0.46 mg/l). Minimum DO value (7.62 mg/l) obtained point-3. BOD varied from 5.13±1.08 to 5.92±0.53. The position where the lowest DO appeared was around 14-18 km.

Index Terms- Oxygen Demand, Non-point source, Biological Oxygen Demand, Nalanda Lake, Nutrient

I. INTRODUCTION

Water is the largest natural resources in the world. But inappropriately low percentage of the total population be able to getting safe and clean water for their daily use. The amount of DO in water is one of the most commonly used indicators of a water body's health. A sufficient supply of DO is dynamic for all higher aquatic life. The problems associated with low concentrations of DO in water have been recognized for over a century (cox, 2003).

Water quality modeling in a Lake has developed from the pioneering work of Streeter and Phelps (1925) who developed a balance between the dissolved oxygen supply rate from reaeration and the dissolved oxygen consumption rate from stabilization of an organic waste in which the biochemical oxygen demand (BOD) deoxygenation rate was expressed as an empirical first order reaction, producing the classic dissolved oxygen sag (DO) model.

Matale District in Sri Lanka has a lot of Natural water resources. Those Natural water bodies has a high amount DO concentration due to the less temperature conditions compare to the other water bodies in Sri Lanka. But Nalanda Lake in Matale district is the one of the lake that highly varied in DO concentration with the seasonal change. Hence, the aim of this work was to identify the DO profile (DO sag curve) in the Nalanda Lake by using Streeter and Phelps equation.

II. METHODOLOGY.

Location-Nalanada Lake is located in Matale district, central province and 28.4Km from Matale town. This is near to Dambulla and Galewella town. The estimated terrain elevation above mean sea level is 400m. Latitude is 7º40' 30.6" and Longitude is 80º 37 ' 1.93 ".

Sample collection-In this study five sample location points were selected according to morphological different. Samples were collected during four weeks. Totally 20 samples were analyzed.

Parameter Analyzed-Initial DO was measured by using DO meter and another sample was collected 300 ml BOD bottle.1 ml of Manganese sulfate and alkali-iodide-azide was added to the sample onsite. The sample was incubation at the 20ºC temperature in 5 days. After five days final DO was measured by using Winkler method.

$$DO = \frac{8.0 \times C_b \times V_b}{V_a \ (V_f - 2.0) V_f} \quad (1),$$

where DO - Dissolved O_2 Concentration in water (mg/l), C_b - Concentration of Sodium thiosulphate solution, V_b - Volume of Sodium thiosulphate solution, V_a - Volume of sample was taken from titration, V_f - Bottle volume with the stopper

BOD = DO (initial) – DO (after incubation 5 days) (2)

Data processing-Finally, the model can be developed by using Streeter-phelps equation. When using collected data from the sample. Initial DO and BOD values were used. A Critical point was indented.

$$D = \frac{k_1 L_0}{k_2 - k_1}\left(e^{-k_1 t} - e^{-k_2 t}\right) + D_0 e^{-k_2 t} \quad (3),$$

Where D= Oxygen deficit in river after time t, L0= Initial ultimate BOD at mix, D0= Oxygen deficit in river after time Zero, K1= De-oxygenation rate constant, K2= Re- oxygenation rate constant, t= time

De-oxygenation rate constant

The BOD is the amount of oxygen required by microorganisms (to respire) as they consume organic matter. The amount of organic waste in a water body is measured by its demand on the water's oxygen resources. (B.A. Cox.2003)

$Kd = K + u\,\eta/H$ (4)

Where Kd = Deoxygenation rate constant, K = BOD rate constant, u = Average stream velocity, m/s, η= Bed-activity coefficient, H = Average depth of stream, m

Reaeration rate constant

$$Ka = 3.9\ u0.5 / H1.5 \quad (5)$$

Where Ka = Reaeration rate constant, u = Average stream velocity, m/s, H = Average depth, m

III. RESULTS AND DISCUSSION

DO concentration

Figure 1 illustrate the dissolved oxygen Variation with the sample point. According to the results are given in Figure 1, 2nd week gives highest DO concentration and 1st week gives lowest DO concentration. In 2nd week samples were collected during a heavy rain period. Therefore, it causes to decrease the temperature of water andalso rain water can easily Dissolve Oxygen. Temperature is inversely proportional to the DO level in the water. Cold water holds more oxygen than warm water. And also DO level vary with altitude. At higher altitudes water has less DO concentration. Because of high altitude has a low atmospheric pressure it is the reason for observing low DO Concentration.

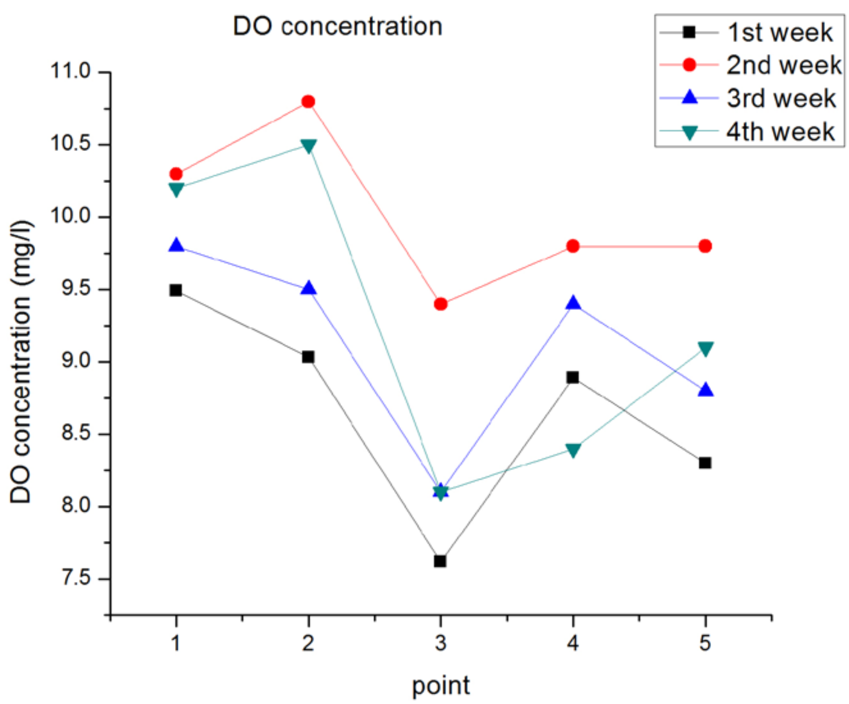

Figure 1: DO Concentration variety

Furthermore in every week, 2nd point samples showed highest DO level and 3rd point samples showed lowest DO levels. Highest DO is equal to 10.8 mg/l. Lowest DO concentration is 7.62 mg/l. This sample location point was highly contaminated with agricultural runoff. Therefore many organic matters are mixed with Lake Water. Aerobic Bacteria is consuming DO to break down these organic matters. As a result of that decrease the DO level in the water.

DO Sag Curve

Oxygen sag curves the curve obtained when the concentration of dissolved oxygen in a river into which sewage or some other pollutant has been discharged is plotted against the distance downstream from the sewage outlet. Samples of water are taken at areas upstream and downstream from the sewage outlet. The presence of sewage reduces the oxygen content of the water and increases the biochemical oxygen demand. This is due to the action of saprotrophic organisms that decompose the organic matter in the sewage and in the process use up the available oxygen. (A dictionary of Biology, 2004).

According to the Oxygen sag curve, initially, DO Concentration is reduced with the distance. This zone name as a zone of degradation. In this zone is a high amount of CO_2 content. After that again DO concentration is increasing, call as a zone of recovery. Due to this, most of the stabilized organic matter are settled as sludge. Between, Zone of degradation and Zone of recovery, is a zone of active decomposition. A minimum concentration occur at one point, call critical point. Dissolved Oxygen Drift and Critical Drift were calculated using Streeter-Phelps equation.

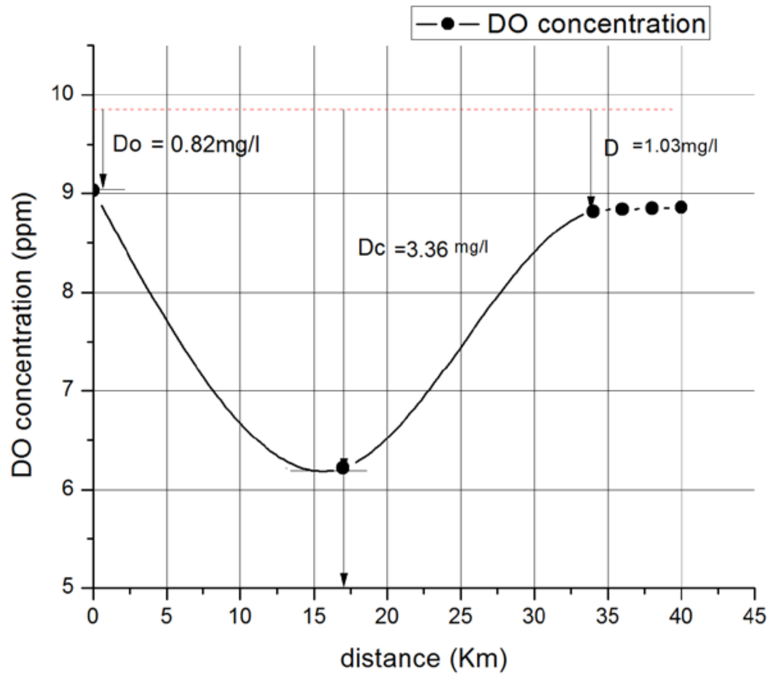

Figure 02: Oxygen Sag Curve 1st week point 02

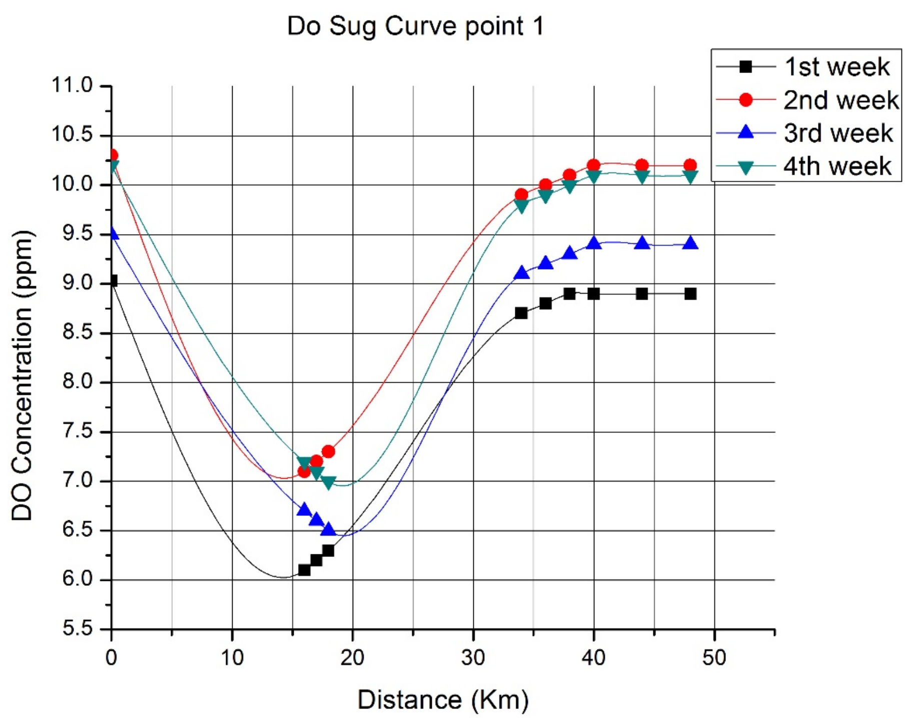

Figure 3: DO Sag Curves in Sample collected Point 01

According to the Figure 3: Initial DO concentration in polluted point 01 nearly 9.88 ± 0.46 mg/l and critical DO concentration is nearly 6.78 ± 0.38mg/l. That critical point was arising nearly 18 ± 1.27 km from the polluted point.

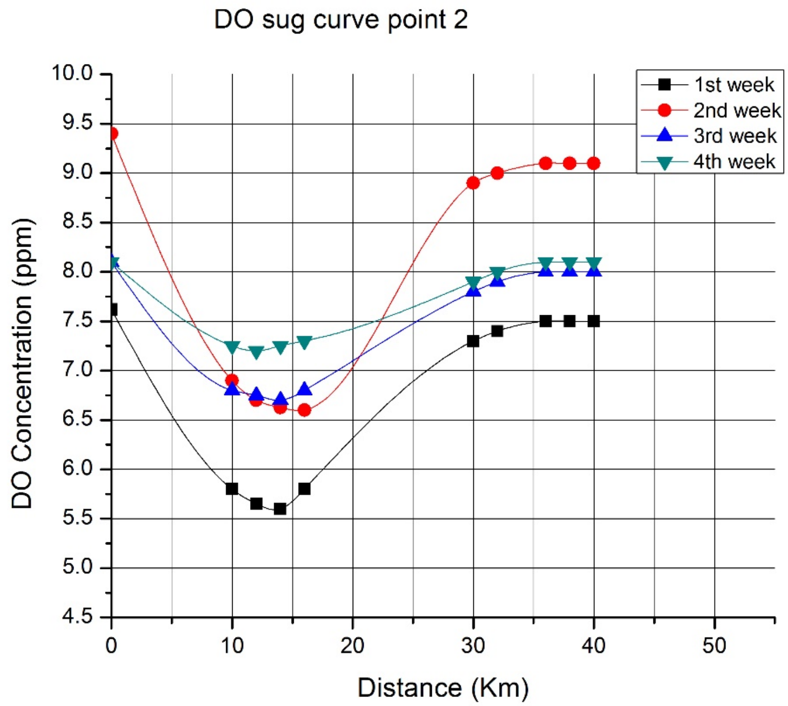

Figure 4: DO Sag Curves in Sample collected Point 02

The figure 4: Initial DO concentration in polluted point 02 nearly 8.31 ± 0.78 mg/l and critical DO concentration is nearly 6.93±0.23mg/l. That critical point was arising nearly 17± 0.69 km from the polluted point.

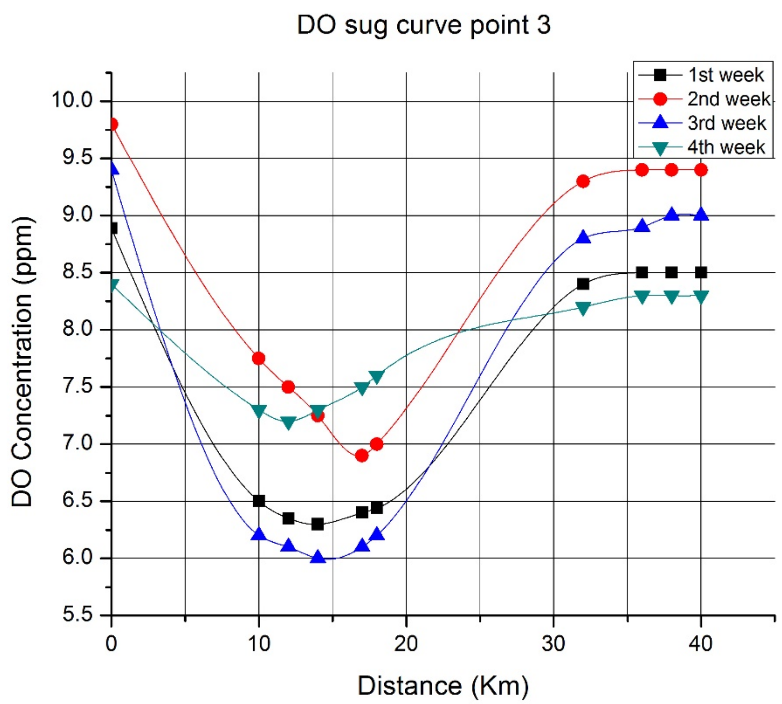

Figure 5: DO sag curves in Sample collected Point 03

According to the Figure 5, initial DO concentration in polluted point 03 nearly 9.12±0.61mg/l and critical DO concentration is nearly 6.41±0.81mg/l. That critical point was arising nearly 17±1.94km from the polluted point.

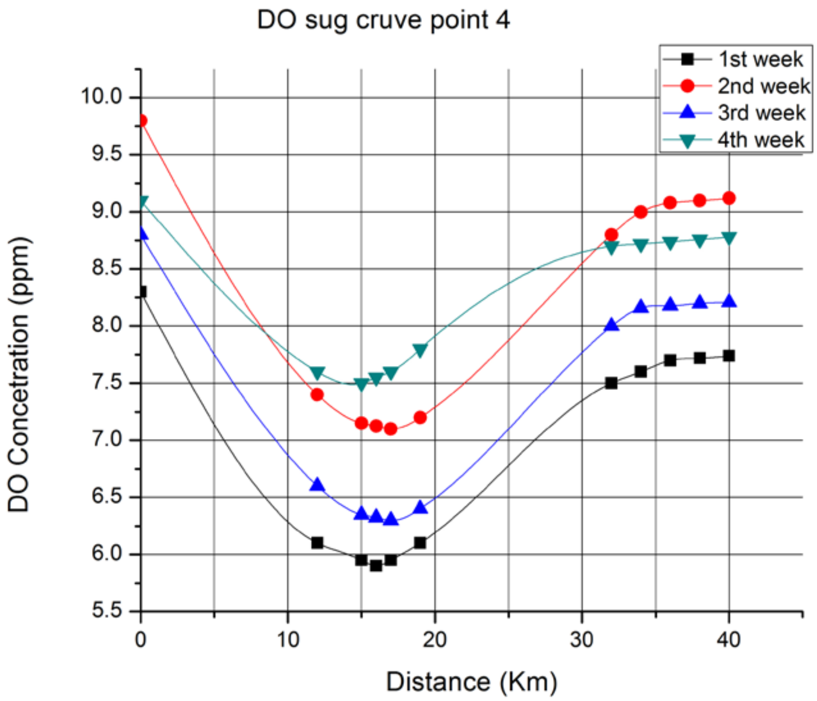

Figure 6: DO sag curves in Sample collected Point 04

According to the graph 4.8 initial DO concentration in polluted point 04 nearly 9±0.63mg/l and critical DO concentration is nearly 7.29±0.22mg/l. That critical point was arising nearly 14±3.10km from the polluted point.

Table 1: Distance where the low DO concentration was occurring.

point	week	Initial DO/ppm	Critical DO/ppm	Distance (Km)
	1	9.03	6.2	17
	2	10.3	7.2	18
1	3	9.5	6.5	18
	4	10.2	7	18
	1	7.62	5.6	14
	2	9.4	6.6	16
2	3	8.1	6.7	14
	4	8.1	7.2	12
	1	8.89	6.4	17
	2	9.8	6.9	17
3	3	9.4	6.2	18
	4	8.4	7.4	12
	1	8.3	5.9	16
	2	9.8	7.1	17
4	3	8.8	6.3	17
	4	9.1	7.5	15

IV. CONCLUSION

The following conclusion can be made as find outcomes based on the results of the current study. Every point has been effect nearby 16km into the polluted point. Because has a low velocity. Therefore, water flowing very slowly. As a result, of that setting time and the distance is increasing. In the rainy season has a high amount of DO concentration in the water. But in dry season less amount of DO concentration has a in the water. Because dissolved Oxygen depends on the temperature.

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