ISSN: 2278-4632
Vol-10 Issue-12 No.03 December 2020

CONCEPT OF WASTE STABILIZATION POND AND IMPACT OF SOLAR AND HYDRAULIC JUMP ON IT

MOUSUMI PUHAN
Assistant Professor, Dept. of Civil Engineering, Aryan Institute of Engineering & Technology, Bhubaneswar
ACHINTYA SAHOO
Assistant Professor, Department of Civil Engineering, Raajdhani Engineering College, Bhubaneswar, Odisha

Abstract:

This study on the effect of solar and hydraulic jump on waste stabilization pond aims at determining increase in solar radiation with hydraulic jump on treatment efficiency in wastewater. In this study, WSP_S with varying sizes and steps were constructed using metallic tanks with inlet and outlet valves. The steps enabled the introduction of hydraulic jump. The hydraulic jumps were created to introduce turbulence thereby adding dissolved oxygen in the pond. Also, the solar reflectors were constructed to increase the incident sunlight intensity. Wastewater samples collected from the outlet of the IWSP was examined for physiochemical and biological characteristics for a period of Eight weeks. The parameters examined are temperature, pH, detention time, dissolved oxygen, faecal coliform, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). This research revealed that the cost of wastewater treatment by using solar reflector and hydraulic jump (steps) enabled WSP_S was approximately one and a third lower than the conventional $WSP_{S.}$

Keywords: Treatment efficiency, Biochemical oxygen demand, Hydraulic jump, Waste stabilization and Pond

INTRODUCTION

Effect of solar and hydraulic on waste stabilization pond is a new technology that evolved as a result of the incorporation of solar reflector and the introduction of hydraulic jump in the conventional waste stabilization pond. The essence is for the purpose of increasing the efficiency and reducing the land area requirement of waste stabilization ponds.

One of the primary objectives of science and engineering has been to harness all the available abundant resources of nature, in order to achieve a reasonable standard of living. However, the contaminations of these resources (air, water, land) have continually posed the gravest pressing environmental problems facing the world today. As a source of greater concern, humans must only depend only on the 0.62% of the earth's total water supply for general livelihood and support of their varied technical and agricultural activities. Therefore, treated wastewater of domestic origin is now being considered and used in many countries throughout the world as an additional renewable and reliable source of water which can be used for various purpose (Anglelakis *et al*., 2003; Oron, 2003). Treated waste water reuse makes a contribution to water conservation and expansion of irrigated agriculture, taking on an economic dimension. This also solves the disposal problems aimed at protecting the environment and public health and prevent surface water pollution (Papadopoulos and Savvides, 2003). The benefits and the potential health and environmental risks resulting from wastewater reuse and the management measures aimed at using wastewater within acceptable levels of risk to the public health and environment are well documented (Asano and Levine, 1996; Marcos do Monte *et al.*, 1996). Therefore, wastewater reuse requires effective treatment and measure to protect public health and the environment at a feasible cost (Sipala *et al.*, 2003; Anderson *et al*., 2001).

Waste Stabilization Ponds (WSPs) are popular wastewater treatment system used for the removal of organics and pathogenic organisms. It consists of a large, shallow earthen basin in which wastewater is retained long enough for natural purification processes to provide the necessary degree of treatment. The natural treatment processes are based on the activities of both algae and bacteria. Its efficiency depends on the availability of sunlight and high ambient temperature which are the prevailing climate conditions in most African communities. The processes that take place in a WSP depend on the efficiency of utilization of sunlight energy through large scale culture and algae in the satisfaction of the oxygen demand of organic waste. Sunlight energy is absorbed by pond algae which through photosynthesis release molecular oxygen into the pond and from aerobic sludge accumulated in the pond as a result of previous bacterial activity.

EXPERIMENTAL METHODOLOGY AND SET-UP

Study Area

Nsukka is situated 6052'N and 7024'E, 70 km North of Enugu, the capital of Enugu state The mean annual values of rainfall, temperature and relative humidity are 1678 mm, 27.1^{0}C and 75.5% respectively. Topographically, it is located in a plateau and escarpment region with ground elevation ranging from approximately 280 m to 530 m above mean sea level located at the north-eastern end of the Nsukka campus of University of Nigeria, with distance of about 800 m from the junior staff quarters, is the treatment plant that was planned for a population growth of 12,000. The construction was planned to take place in two phases. The plan was to construct a waste treatment plant for a population of 6,000 to 8,000 over a period of ten years. It was constructed and commissioned in April and November 1961 respectively while it started its operation in January 1962. The treatment plant consists of a screen (6 mm bar racks set at 12 mm center) with two imhoff tanks, each measuring about 6.667x 4.667x10 m, It was designed to take care of population range 3,000-4,000. The sedimentation compartment was designed for a surface settling rate of 29.3

ISSN: 2278-4632
Vol-10 Issue-12 No.03 December 2020

m^3 day /and detention time of 112 $m^{3/}h$. The digestion compartment storage volume is 0.057 m^3/capita while the period of digestion is 30 day at an average temperature of 27^0C. The imhoff tank which should be dredged every 5 years was last dredged in 1965. The sludge from the treatment plant is desludged from the imhoff tank once every 10 days into one of the 4 drying beds, so that the beds are loaded at 40 days interval. The beds have a total area of 417 m^2. The effluent from the imhoff tanks enters the two facultative waste stabilization pond (WSPS). The plant treats mainly domestic wastewater and has not been desludged since it started operation. Although its efficiency has deteriorated, effluent from the pond is used for uncontrolled vegetable irrigation by some village dwellers.

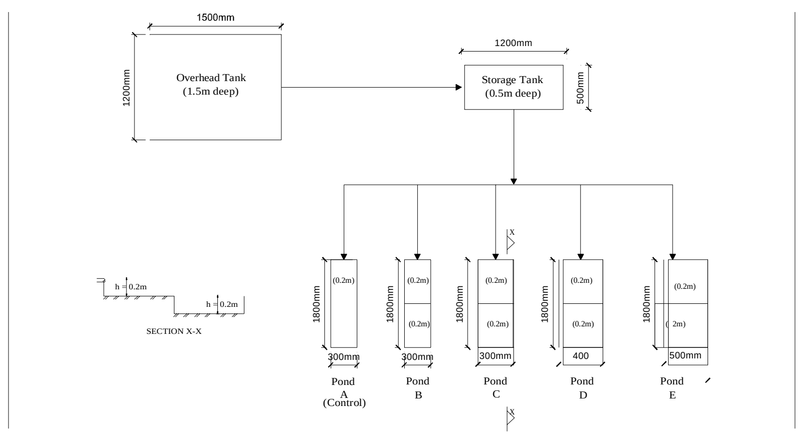
Experimental Investigation and Set Up

In the course of carrying out the research, different sets of integrated solar ponds with dimensions as shown in Table 1 and Figure 1

Table 1: Detailed Description of Various Ponds due to Width Effect

Experimental Ponds	Size	Characteristics	Purpose
A	1 x 0.3 x 0.2	No solar reflector	Control
B	1 x 0.3 x 0.2	Jump without reflector	Measure the effect of hydraulic jump
C	1 x 0.3 x 0.2	Solar reflector	Measure the effect of solar reflector and hydraulic jump
D	1 x 0.4 x 0.2	Solar reflector	Measure the effect of solar reflector and hydraulic jump
E	1 x 0.2 x 0.2	Solar reflector	Measure the effect of solar reflector and hydraulic jump

Figure 1: Schematic Diagram of Experimental Setup Due to Width Variation



ISSN: 2278-4632
Vol-10 Issue-12 No.03 December 2020

below, with one sewage tank (1.2 m x 0.5 m x 0.5 m) that receives its influent from an overhead storage tank with (1.2 m x 1.5 m x 1.5 m) were constructed for the experiment. Four out of the five ponds were constructed with tilt frame at 15° for fixing of polished aluminum sheets of size 0.2 m x 1.0 m to act as solar reflector, with each pond having one reflector each at the outlet position. Subsequently, tilt frames with solar reflectors are studied at angles 25°, 35° and 45° for the four ponds. One out of the five of the ponds was constructed without the step and solar reflector to serve as control. The two storage tanks was usually filled to supply the five sets of ponds with sewage from the facultative pond of the University of Nigeria, Nsukka through an underground pipe with the aid of a water pump powered by a generator.

RESULTS AND DISCUSSION

Chemical Oxygen Demand (COD)

Results obtained from laboratory analysis show that pond E (see Figure 2) has the best treatment efficiency, followed by Pond D, C and B, while pond A (the control) has the lowest efficiency . Pond E,D, were exposed to same amount of intensity of sunlight and hydraulic Jump but the high level of DO of pond E aided in its best performance.

Even though pond A, B and C have the same geometry, pond C shows high efficiency than others due to the increase in the solar reflection due to the reflector attached to it. The minimum and maximum values of COD for pond A were 216 mg/l and 432 mg/l, respectively. Pond B has 164 mg/l and 324 mg/l as its minimum and maximum values. While pond C has 136 mg/l and 300 as its minimum and maximum values.

Biochemical Oxygen Demand (BOD)

High efficiency of BOD removal in Pond E followed by D, C, B and A as shown in Figure 3 was as a result of the hydraulic jump coupled with the solar reflector and its high level of DO.

Although Pond A, B, C have same geometry, there was a remarkable difference in the treatment efficiency of Pond C compared to B and A, which are of same size. The minimum and maximum concentrations of BOD in pond A were 170 mg/l and 280 mg/l respectively, and 110 mg/l and 240 mg/l for Pond B, respectively.

Coliform

Samples were collected and analyzed from the hydraulic and solar ponds in the laboratory. The graph of Figure 4 shows that pond E with largest width and has both solar reflector and hydraulic jump fitted into it gave the best coliform removal. This result was followed by pond D, C, B and A having the least efficient. Coliform bacteria was higher in Pond A having maximum and minimum coliform as 43 per 100 ml and 2400 per 100 ml Than Pond B and C even though they have the same geometry. This was as a result of hydraulic jump and solar reflector present in B and C, respectively.

Dissolve Oxygen

The dissolve oxygen graph (Figure 5) shows that Pond C has the least dissolve oxygen even Though it has same geometry with Pond A, B this was as result of the solar reflector present in the pond. Pond B has the highest dissolve oxygen due the hydraulic jump created in the pond followed by Pond E and D. Minimum DO

ISSN: 2278-4632
Vol-10 Issue-12 No.03 December 2020

values for Pond E and D were 2.2 mg/l and 1.4 mg/l respectively. While the maximum values for their DO were 7.2 mg/l and 7.0 mg/l, respectively

E. coli

From Figure 6 it shows that there was a higher degree of removal of *E. coli* in Pond E compared to D, C, B and A because of its shallow width and the presence of solar reflector and hydraulic jump attached to it, the reflector increased the temperature while the jump introduced the required dissolved oxygen for microbial activities. It aided in the higher rate of degradation, thereby leading to higher treatment efficiency of the Pond.

Figure 2: Efficiency of COD Removal Versus Time

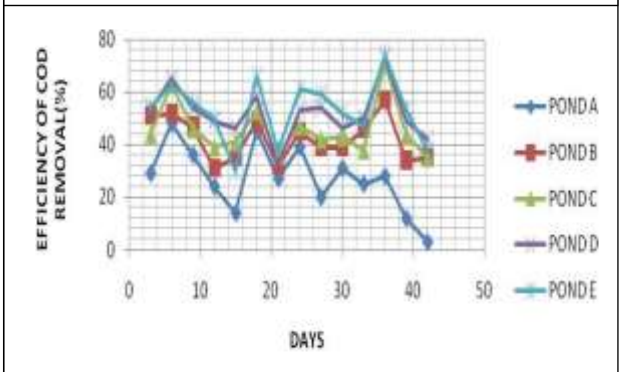


Figure 3: Efficiency of BOD Removal Versus Time

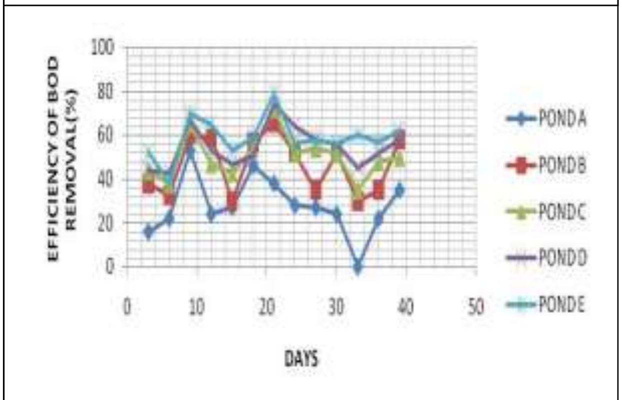


Figure 4: Efficiency of Coliform Removal Versus Time

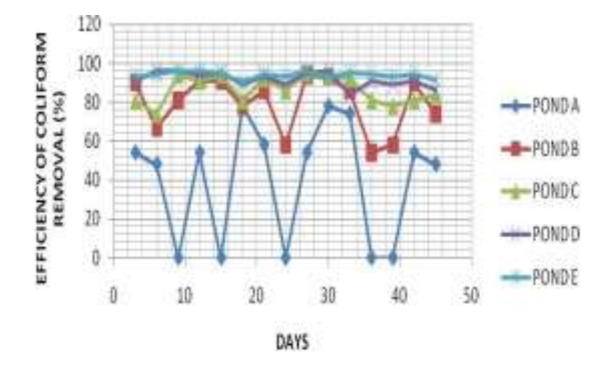


Figure 5: Dissolve Oxygen Variations Versus Time

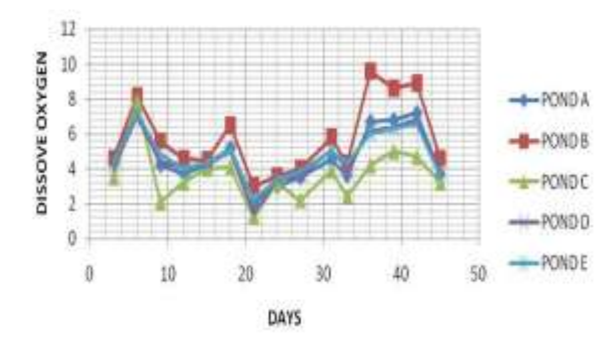
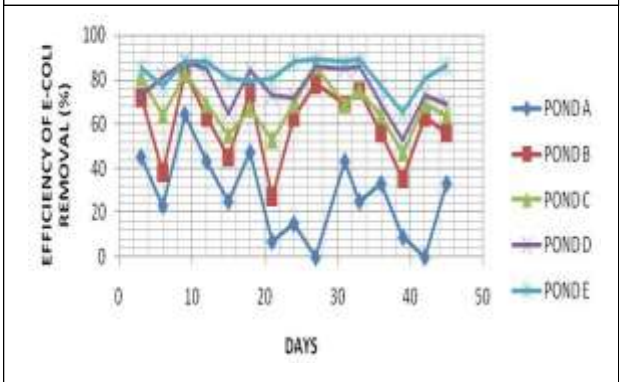


Figure 6: Efficiency of E -Coli removal versus time



Comparing Pond B and C, the minimum and maximum values of *E. coli* concentrations of Pond B were 7 per 100 ml and 75 per 100 ml, and 7 per 100 ml and 43 per 100 ml ,respectively.

Figure 7: Efficiency of Suspended Solids Removal Versus Time

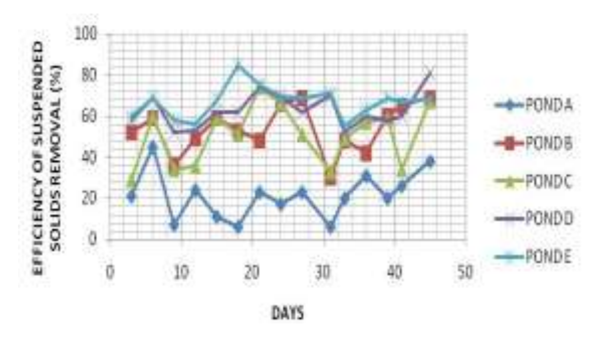
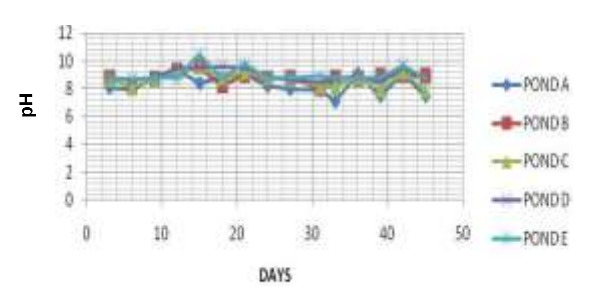


Figure 8: pH variations Versus Time



CONCLUSION

Experimental investigations were carried out by designing the ponds based on facultative ponds approach to treat wastewater using solar energy and hydraulic jump. Pond with fitted reflectors were constructed with metals and hydraulic created on it. The reflectors were made with fitting aluminum foil to concentrate solar radiation on pond C, D, E and jumps created on Pond B, C, D, E while pond A is without a reflector and a jump to act as the control experiment and Pond F as an inlet.

From the experimental result gotten from the water resources and Environmental Engineering lab, it was confirmed that introduction of sunlight and solar and jumps (steps) has a serious effect on wastewater treatment, its effect was higher compared with other methods of wastewater treatment. But from samples collected from pond A, B, C, D, and E (inlet), it shows that treatment was higher in solar and jump Pond E due to the jump and solar attached to it and its increase in DO followed by D . Due to the increase in solar radiation and jump, the treatment was higher in Pond D than Pond A the control.

Cost benefit analysis was carried out which proved that ponds fitted with solar reflector and jump (steps) created will take less land area than conventional pond.

REFERENCES

1. Abis Karen L (2002), “The performance of facultative waste stabilization ponds in the United kingdom”, Ph.D. Thesis, U.K. University of Leeds.
2. Acher A E, Fischer R Turnheim and Y Manor (1997), “Ecological friendly wastewater disinfection techniques”, *Water Res*., Vol. 31, pp. 1398 – 1404.
3. Agunwamba J C, Egbuniwe N and Ademiluyi J O (1992), “Prediction of the Dispersion Number in Waste Stabilization Ponds” Water Research (G.B.), Vol. 26, No. 1, pp. 85-90.

ISSN: 2278-4632
Vol-10 Issue-12 No.03 December 2020

4. Agunwamba J C and Tanko J A (2005), "Waste Stabilization pond Design Using Geometric Programming", *Technol. Dev*., Vol. 9, pp. 123-128.

5. Agunwamba J C and Ogarekpe N M (2010), "The Effect of Hydraulic Jump On the Performance of Waste Stabilization Ponds", *J Waste Water Treatment Analysis,* Vol. 1(01), pp. 1-4.

6. Agunwamba J C, Utsev J T, and Okonkwo W I (2009), "Solar Enhanced Wastewater Treatment in Waste Stabilization Ponds", *Water Environ. Res.*. Vol. 81 (5), pp. 540-544.

7. Anderson I A, J Crook, C Davies, R Holtquist, B Jimenez-Cisneros, W Kennedy, B Sheikh and B Vander Merwe (2001), "Climbing the ladder: a step-by-step approach to international guidelines for water recycling", *Wat. Sci. Tech.,* Vol. 43(10), pp. 1-8.

8. Angelakis A N, L Bontoux and V Lazarova (2003), "Challenges and prospective for waste recycling and reuse in EU countries", *Wat. Sci. Tech. Water Supply,* Vol. 3(4), pp. 59-68.

9. APHA, AWWA, and WPC (Ed.) (1985), Standard Methods for the Examination of Water and Wastewater, Washington D.C. (15th Ed.) USA.

10. Aris R (1994), *Mathematical Modeling Techniques*, New York, Dover.

11. Asano T and A D Levine (1996), "Wastewater reclamation, recycling; past, present and future", *Wat. Sci. Tech.,* Vol. 33(10-11), pp. 1-14.

12. Awachi I R N and Okeke C E (1990), "New Empirical Solar Model and its Use in Predicting Global Solar Irradiation", *Nigerian J. solar Energy,* Vol. 9, pp. 143-156.

13. Benchokroun S, Imziln B and Hassani L (2003), "Solar Inactivation of Mesophilic Aeromonas by Exogenous Photooxidation in High-Rate Algal Pond Treating Wastewater", *Microbiol.,* Vol. 94 (3), pp. 531-538.

14. Bunce N J (1991), "Environmental chemistry", pp.183-214. Wuerz Publishing Ltd., Winnipeg, Canada.

15. Chanson H (1994), *Hydraulic Design of Stepped Cascades, Channels, Weirs and Spillways,* Pergamon, Great Britain, pp. 44 - 60.

16. Clesceri L S, Greenberg A E and Eaton A D (1998), *Standard methods for the examination of water and wastewater,* 20th Ed., American Public Health Association, Washington DC.

17. Conroy R M, Elmore-Meegan M, Joyce T, McGuigan K G and Barnes J (1996), *Solar disinfection of drinking water and diarrhea in Maasai children: a controlled field trial.* Lancet.