

A LOW-COST TEMPERATURE CONTROL UNIT FOR WASTEWATER RESPIROMETER

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ABSTRACT

A low cost electromechanical device for maintaining constant thermal background in the reaction and control chambers of a wastewater respirometer is described. It consists of a water bath unit with a temperature control over the range 18^oC to 32^oC and a reverse mode peristaltic pump operated at a maximum discharge of 120 ml/min. The water bath is incorporated with an automatic aquarium heater. A thermometer is provided to monitor the temperature profile in the water bath. The peristaltic pump can alter the fluid circulation between the respirometer and water bath. The pump head devised with a replaceable silicon tube of 8mm diameter which is driven by a 9V DC motor.

Keywords: Low cost, Water bath, Peristaltic pump, Respirometer, Reversing switch.

1. INTRODUCTION

Oxygen uptake rate (OUR) measurement is a means of quantifying the biodegradation kinetic of organic materials present in the wastewater. It can be easily measured from the respirometric data obtained from a simple respirometer (Roppola *et al.*, 2006). OUR can provide more information concerning wastewater characteristics, treatment plant performance, and degradability of special concentrated streams as well as parameters needed for mathematical models in order to predict possible optimizations of a treatment plant. Any small change of temperature in the reactor of a respirometer may significantly influence the biodegradation kinetics of wastewater microbes (Anantheswaran *et al.*, 1984; Gautamet *et al.*, 2007). Therefore, it is utmost important to maintain constant temperature around the reactor during the experiment. Temperature control units are extensively used in different types of laboratory investigations related to a wide range of disciplines e.g. Civil and Environmental Engineering, Chemical Engineering, Chemistry, Biochemistry, Microbiology etc. A number of commercial temperature control units are available in the market (Water bath catalogue, 2012). But the facilities offered by these products are limited to a certain extent. Temperature control unit discussed in this paper is a specially designed device in accordance with the requirements of 'BIOSUST' respirometers that are locally fabricated at the Centre for Environmental Process Engineering of Shahjalal University of Science and Technology, Sylhet to use in the study of biodegradation process of wastewater and biosolid materials (Islam *et al.*, 2010).

2. EXPERIMENTAL

The temperature control unit mainly consists of 1) a water bath with an automatic aquarium heater and 2) a reverse mode peristaltic pump. Figure 1 shows the major components of the unit whereas figure 4 illustrates the operational setup of the apparatus.

2.1 Water bath unit

The main tank of water bath is made of 20 gauge metal sheets insulated with styrofoam and stands on a level wooden platform. A normal thermometer is incorporated for monitoring temperature profile during the experiment. A fully submersible automatic aquarium heater is placed inside the water tank. The typical components as well as the technical specifications of the water bath are provided in the Table 1.

2.2 Peristaltic pump unit

The peristaltic pump can alter the water flow from water bath to experimental reactor of the respirometer. A number of commercial peristaltic pumps are available in the market (Peristaltic pump catalogue, 2012). However, cost and efficiency provided by the present pump is fairly compatible to the requirements of a typical wastewater respirometer. Figure 2 shows the pump head assembly with the accessories. A DPDT (Double Pole,

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Double Throw) switch wired up as reverse circuit for the operation of the motor is shown in Figure3. Moreover, a list of components as well as the technical specifications of the pump is provided in the Table 2.

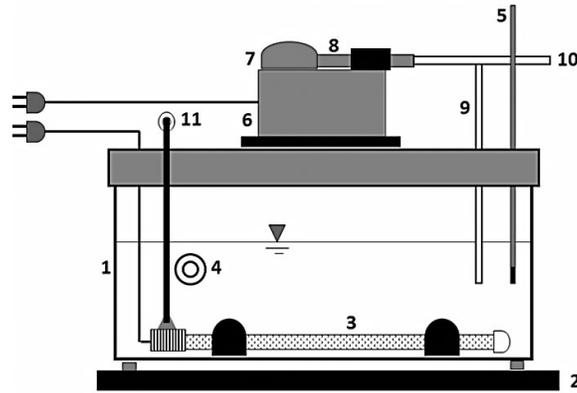


Figure1: ‘BIOSUST’ temperature control unit (1. Water tank with lid, 2. Platform, 3. Automatic aquarium heater, 4. Outlet pipe, 5. Thermometer, 6. Peristaltic pump, 7. Pump head, 8. Silicon tube, 9. Pump Inlet pipe, 10. Pump outlet pipe, 11. Temperature tuning knob)

Table 1: Technical specifications of the water bath unit

Subunits	Particulars	Description
1. Water tank	Dimensions	360 x 190 x 270 mm
	Weight	2.5 kg
	Thermal insulator	Styrofoam of 10 mm thickness
	Capacity	9 liter
2. Automatic aquarium heater	Brand Name	Weipro
	Model no	HA-200w
	Type	Submersible
	Watt	200 w
	Volt	AC 230V/50Hz
	Materials	Borosilicate glass
	Temperature range	18-32°C ±1°C
3. Platform	Dimensions	400x250x35 mm
	Materials	Wooden frame

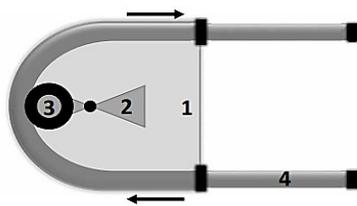


Figure2: Peristaltic pump head (1. Head chamber, 2. Shaft, 3. Roller, 4. Silicon tube)

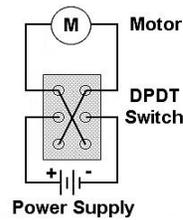


Figure3: Circuit diagram of a DC motor reversing switch

3. RESULTS AND DISCUSSION

3.1 Water bath unit

Water bath is a device or a vessel for regulating the temperature of any experimental vessel subjected to heat, by surrounding it with another larger tank containing water which can be kept at a desired temperature. Therefore, ambient temperature profile supported by a water bath should be monitored periodically to ensure correct operation of the device for a successful respirometric investigation. Figure 5 represents the prolonged temperature profile usually achieved by the whole system and it seems that the water bath can maintain constant thermal background over a desired period of time, although, more than one hour is required to reach at the optimum

temperature level. Here the initial temperature is recorded as 18°C and the target temperature is fixed as 30°C. However, a temperature lag of 2.5°C is observed in the reactor vessel which can be minimized by tuning the heater temperature value 2.5°C higher than the target temperature.

Table 2: Technical specification of the peristaltic pump

Subunits	Particulars	Description
1. Main pump	Dimensions	130 x 100 x 110 mm
	Weight	1 kg
	Pump head	Single roller mounted on an eccentric portion of a drive shaft
	Motor type	DC 9 volt Motor (input voltage 220 V AC)
2. Silicon Tube	Discharge capacity	120 ml/min (max)
	Tube size	Inner dia 6mm; outer dia 8mm
	Tube material	Silicone
3. Inlet/outlet pipe	Pipe size	Inner dia 6mm; Outer dia 8mm
	Pipe material	Plastic

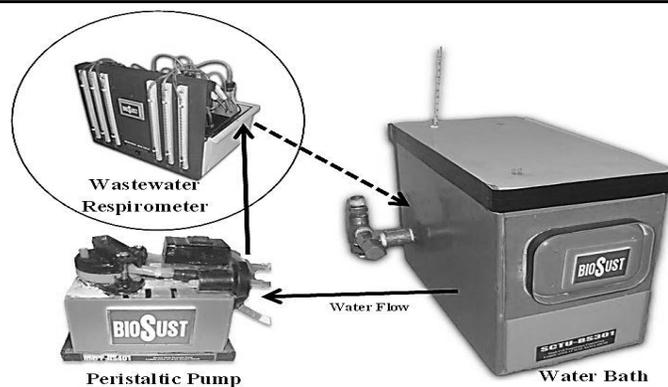


Figure 4: Operational setup of the temperature control unit with respirometer

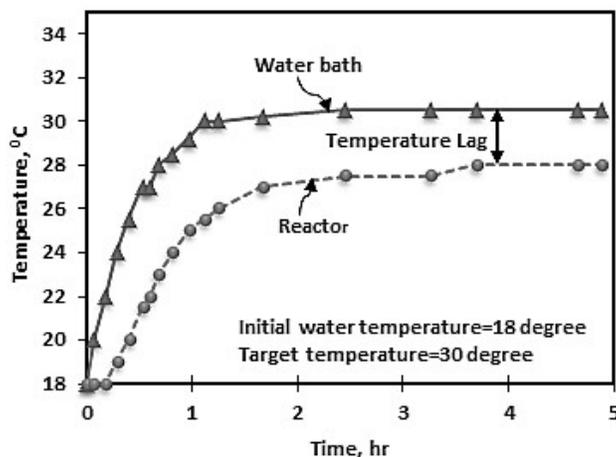


Figure 5: Performance test curve for water bath (Temperature basis)

3.2 Peristaltic pump unit

Peristaltic pump plays a significant role to ensure quick distribution of temperature in water by reversing the flow time to time between the tank and respirometer. Figure 6 shows the discharge capacity of the peristaltic pump in both clockwise and anticlockwise rotation. At full operational condition, the pump can discharge 120ml of water per minute in clockwise rotation while in opposite direction it gives about 113 ml/min. Therefore, it is quite clear from the result that the discharge trend is almost typical in both conditions which ensures good reversing operation of the pump and both of the discharge capacity is quite sufficient for rapid thermal diffusion within the system.

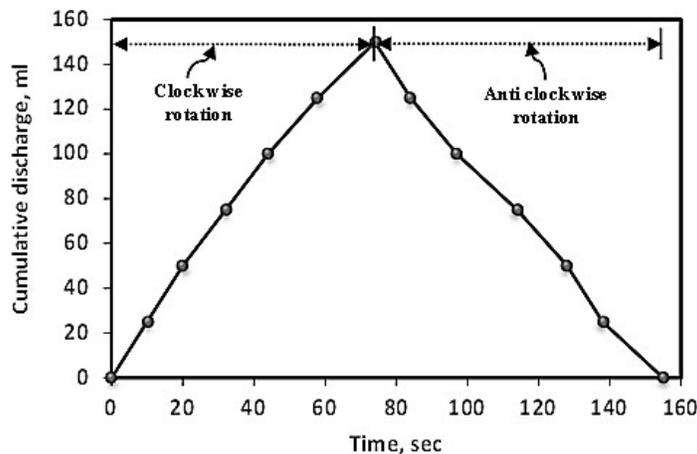


Figure 6: Performance test curve for peristaltic pump (Discharge basis)

3.3 Comparison of Price

BIOSUST products are fabricated with local materials at a very cost effective way. Only the aquarium heater is purchased from the local market. Table 3 shows the material cost of BIOSUST products and market price of various commercial temperature control units and other accessories (Latest price list is collected from Paradise Scientific Company, Bangladesh).

Table 3: Price list of different commercial and BIOSUST temperature control units

Product items	BIOSUST Products (Material cost, BDT)	Commercial Products (Market price, BDT)
Water bath	1,500-3,500	5,000-35,000
Peristaltic pump	500-1,500	3,000-8,000

It is clear from the above price list that BIOSUST products are comparatively cheap than the commercial ones. If an effective performance could be ensured, these local BIOSUST products would be a low-priced alternative for biomonitoring test activities using respirometer in our institutes and industries.

4. CONCLUSION

The study revealed that the low-cost water bath facilitated with the reverse mode peristaltic pump can be successfully used to maintain constant thermal background during biodegradation kinetic study of wastewater using the 'BIOSUST' and other commercial brand respirometers available in the market.

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