Use of Water Melon Seeds in Water Treatment

M. M. Manyuchi[1,2]*
[1] BioEnergy and Environmental Technology Centre, Department of Operations and Quality Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[2] Department of Chemical and Processing Engineering, Faculty of Engineering, Manicaland State University of Applied Sciences, Zimbabwe
mercy.manyuchi@gmail.com

T. Chikomo[3]
[3] Department of Chemical and Process Systems Engineering, Harare Institute of Technology, Zimbabwe
chikomotawanda@yahoo.com

C. Mbohwa[1]
[1] BioEnergy and Environmental Technology Centre, Department of Operations and Quality Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
cmbohwa@uj.ac.za

E. Muzenda[1,4]
[1] BioEnergy and Environmental Technology Centre, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[4]Department of Chemical, Materials and Metallurgical Engineering, Faculty of Engineering and Technology, Botswana International University of Science and Technology, P Bag 16, Palapye, Botswana
emuzenda@uj.ac.za; muzendae@biust.ac.bw

Abstract

This paper presents the treatment of municipality water using watermelon seeds as natural coagulants and bio filter in the water treatment process. A significant reduction in water physicochemical parameters was observed notably the BOD and COD by more than 79% to meet the WHO guidelines for drinking water. A process treating 25 m^3/day of the water for portable uses was processed and the design of the bio filter presented. An economic assessment for applying this technology in water treatment showed a payback period of 10 months with a rate of return of 28% upon investing $295 000.00.

Keywords: Biological filter; coagulant; watermelon seeds; water treatment.

1. Introduction

Watermelons are a popular seasonal plant in the sub-Sahara and their seeds can be used as effective water purifiers because of their adsorbent properties like most indigenous seeds (Sciban et al., 2006; Malunjkar and Ambekar, 2015). They treat water on two levels, acting as both a coagulant, an antimicrobial agent and can be used to enhance the filtration process during water treatment (Banerjee et al., 2012; Manyuchi and Phiri, 2014; Muhammad et al., 2015). In wastewater treatment, coagulants are used to aid in the separation of suspended solids. These particles are very minute in nature and their stability is dependent on the electric charge between them as well as their size (Deepika et al., 2013; Salem et al., 2014). When these suspended particles have been subjected to coagulants, filtration is the most important unit process in the removal of the solid matter. In water treatment, it is used to purify the Filtration, allows for the effective treatment of wastewater to come up with a clean effluent. This study proposes a process design that can be used to treat water for portable use using the water melon seeds as a bio filter. Furthermore, an economic assessment was carried out to access the viability of applying the technology at an industrial scale.

2. Experimental

2.1 Preparation of the Watermelon Seeds Coagulant

A methodology clearly described by Muhammad *et al*. (2015) was adopted for preparation of the coagulant. Fresh watermelon seeds were obtained from a local market and sliced to remove the seeds. The seeds were sun dried for a week and then crushed into minute particles. The oil from the watermelon seeds was removed via Soxhlet extraction using hexane extraction for 6 hours. The cake obtained was then washed with distilled water and dried in an oven for use as coagulant. A sample of 10 mg of the coagulant was used per liter of water which was recommended as the optimal loading by Muhammad *et al*. (2015).

2.2 Water Physicochemical Parameters Analysis

Raw water for experimental purposes was obtained from the municipal water. The water physicochemical parameters were determined before and after treatment with the watermelon seeds in accordance to APHA (2005). The parameters measured included biological oxygen demand (BOD), chemical oxygen demand (COD), pH, total dissolved solids (TDS) and the electrical conductivity. The water melon seeds proximate analysis was also done.

3. Results and Discussion

3.1 Proximate Analysis of the Watermelon Seeds

The proximate analysis for the dried watermelon seeds is indicated in Table 1. The crushed watermelon seeds had a moisture content value of 6.7%, protein composition of 27.6%, fat composition of 47.5% and ash content of 4.5%. It is the protein in the watermelon that allows it to act as a natural coagulant.

Table 1. Watermelon seeds proximate analysis

Parameter	Value
Moisture	6.7 ± 0.1
Protein	27.6±0.5
Fat	47.5±0.2
Ash	4.5±0.1
Crude fiber	3.4±0.1
Carbohydrate	9.6±0.2

3.2 Effect of Watermelon Seeds on Water Treatment

The use of watermelon seeds as a coagulant to treat the municipal water resulted in portable water that met the World Health Organisation (WHO) standards for portable water (Table 2). This makes the use of the watermelon seed as a coagulant attractive especially to the rural folks since it is a low cost technology applying the local fruit. A significant reduction in BOD, COD, TDS and EC was observed after treating the water.

4. Process Design

The use of watermelon seeds in water treatment first allows for flocs to be formed. This is through the flocculation of tiny particles of suspended solids to remove turbidity, colour and bacteria. The flocs formed are then sedimented first then passed through the bio filter which is also made of the water melon seeds. A process treating 25 m^3/day of municipal water was considered for application of the watermelon seed. The process designed is mainly based on the depth bed filters and on the filter column. The water from the city council is received at the control section then it enters the filter medium where it is treated for it to be more portable for consumption then the purified water will be then feed into the water system of the institution. The overall process description is shown in Figure 1. During the treatment process, the watermelon seeds are used in both the coagulation tank and the filter. The filter bed if properly maintained can last up to 5 years.

Table 2. Comparison of the experimental data with the who recommended limits for portable water

Parameter	Before treatment	After treatment	% change	WHO standards [5]
pH	7.1	7.0	0.4	6.5-8.5
BOD	25.7	2.2	91.5	<6
COD	10.3	2.1	79.5	<10.0
TDS	80.6	49.0	39.3	500
Conductivity	879.3	302.2	65.6	1400

*All units are in mg/L except for pH and conductivity

The mass balance was done in order to determine the amount of water which was required to enter into the column per the particular time of each treatment process.

Mass out – Mass in – Mass consumed – Mass generated = Mass accumulation

Assumptions: there was no mass which was generated, accumulated and consumed inside the column. Therefore, the overall mass balance of the filtration column will be represented as follows: Mass in = Mass out

The overall mass balance of the water purification process was based on the filtration process and this was mainly based on the product water yield and also the capacity of the process of 25 000 litres per day as shown in Figure 1.

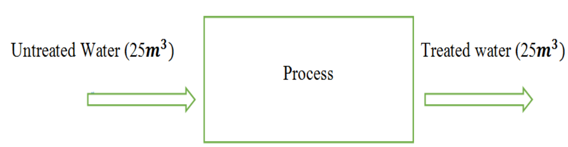

Figure 1. Overall mass balance

The basis of the output was the design expected output which is 25 m^3/day of portable water for consumable use.

5. Economic Analysis

A process treating 25 m^3/day of water using the watermelon natural coagulant was considered for the economic analyses. Economic viability of a project is determined is based on the profit of the investment and its financial sustainability, this can be done using financial indicators like the payback period, return on investment and the net present value (Peters and Timmerhaus, 1993).

5.1 Costs of Operation

It is critical to know the operation costs of running a project so as to determine the economic viability of running a project. These costs vary from the raw material requirement, services required as well as the capital cost estimation. Normally additional information required can be obtained from the flow sheet. The project cost of production includes the items listed in Table 3. The operating costs are into two groups, which are fixed operating costs and variable operating costs.

Table 3. Summary of costs

Item	Cost ($)
Fixed costs	61 600.00
Variable cost	12 142.00
Capital investment	11 218.00
Total	84 960.00

The working capital of the project is at 10% of investment which translate to $ 1 121.80. Table 4 gives a summary of the selling price as well as the plant operating capacity.

Table 4. Summary costs and projected cash flows

Item	Value
Selling price	$ 0.07/litre of purified water
Plant capacity	$ 2 500/day
Operating time	8 hours/day
Operating days per year	360
Projected cash inflows and outflows	
Savings on water	$450 000.00/year
Savings paper work	$ 22/year
Costs incurred due to bed changing	$50 216/year
Costs incurred due to maintenance	$22 600/year
Net inflows	(450 000+22) - (50 216+22 300) = $377 506/year

5.2 Return on Investment

The Return on Investment (ROI) is basically a measure of the amount of capital invested in the project and is used to evaluate the efficiency of the investment in relation to its cost. . The ROI can be defined as the ratio of the net annual profit to the total investment.

$$\text{ROI} = \frac{\text{Earnings} - \text{Initial investment}}{\text{Initial investment}} = \frac{377\ 506 - 294\ 927}{294\ 927} \times 100 = 28\%$$

The ROI of 28% was very low indicating the economic potential of using water melon seeds in water treatment as a coagulant.

5.3 Payback Period

The payback period refers to the time at which the initial cash outflow of an investment is recovered from the initial cash investment. Payback period can be defined as the ratio between the initial investment and the cash inflow per 'given period.

$$\text{Payback Period} = \frac{\text{Initial Investment}}{\text{Cash Inflow per Period}}$$

The calculated payback period for this study was 10 months indicating an economic viable process.

NB: Since this is a process improvement on the part of the existing process, therefore less payback time is justifiable.

5.4 The Net Present Value

The Net Present Value (NPV) is an economic indicator which is defined as the difference between the present cash inflow values and the present cash outflow values. The NPV is a capital budgeting technique and is calculated as indicated below:

$$\text{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

Where C_t = net cash inflow during the period t; C_o = total initial investment costs; r = discount rate, and t = number of time periods

The NPV in this study was $7 438.33. A positive net present value indicates that the projected earnings generated by a project or investment exceed the anticipated costs (also in present dollars). This investment is profitable since it has a positive NPV.

6. Conclusion

Watermelon seeds which are abundantly available in Zimbabwe can be used to purify water for portable uses in Southern Africa. The watermelon seeds when employed as a coagulant which is chemical free can significantly decrease the COD, BOD, EC and TDS to meet acceptable limits of portable water. An economic assessment of applying this technology indicated a payback period of 10 months and a rate of return of 28% after investing $294 927.00 showing the economic viability of applying this technology.

Acknowledgement

Tawanda Chikomo is acknowledged for conducting the experiments.

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Biographies

Mercy Manyuchi is a Researcher at the University of Johannesburg in South Africa. She holds a Doctorate Degree from Cape Peninsula University of South Africa, a Master of Science Degree from Stellenbosch University and a Bachelor of Engineering Honors Degree from Zimbabwe. Her research interests are in waste to energy technology, value addition of waste biomass and renewable energy technologies.

Charles Mbohwa is a Professor of Sustainable Engineering and Energy Systems at the University of Johannesburg.

Edison Muzenda is a Professor in Professor in Chemical and Petrochemical Engineering at the Botswana University of Science and Technology. He is also a visiting professor at the University of Johannesburg.