A Review of Bicycle Operated Water Purifier

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Abstract— This paper analyses the design of a pedal operated water filtration system to be used by local dwellers. It works on the principle of compression and sudden release of a tube by creating negative pressure in the tube and this vacuum created draws water from the sump into the pump while rollers push the water through to the filter where adsorption takes place to purify the water. The design comprises of a peristaltic pump powered by pedalling, a filter and hose or flexible tube. As the operator sits on the seat and pedals, the pedal crank transfers the motion to the rotor thus the rollers and the tube is squeezed by the set of rollers to move the fluid. This design will reduce the labour, cost and weariness caused by transporting and sanitizing drinkable water for use.
Key words: Filtration System, Pedal Crank, Peristaltic Pump, Sump, Local Dwellers, Pure Water

I. Introduction

Safe drinking-water and adequate sanitation services to all is perhaps the greatest development failure of the 21st century. The most egregious consequence of this failure is the high rate of mortality among young children from preventable water-related-diseases. Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefit to health. Nearly, one billion people suffer needlessly without access to safe drinking water and over five thousand children die each day because of water related diseases. Water-related diseases: caused by insect vectors, especially mosquitoes, that breeds in water; include dengue, filariasis, malaria, onchocerciasis, trypanosomiasis and yellow fever. (Peter H.G., 2002). Drinkable water sources are distant from most villages in India. Women and children especially spends hours of labour just to meet the basic needs of their families walking five miles and more to nearby towns just to have access to drinkable (purified) water. Some well to do inhabitants in these villages travel long distances with motor bikes and trucks which consume fuel and pollute the air. Moreover, a family of five needs a minimum of fifteen gallons of water each day. The only way to sanitize the stream water available to these villages is by boiling which also consumes precious resources and contributes to deforestation since the only source of energy for boiling this much water is firewood and charcoal (Payment and Hunter, 2001; Howard, 2006). However, a number of studies from low-income countries have indicated that improved access to water – and the resulting increases in the quantity of water or time used for hygiene – are the determining factors of health benefits, rather than improvements in water quality (Curtis and Cairncross, 2003). The objective of this work is to design a mechanism to be used with water filter to supply purified water for villages and remote places by harnessing the human pedal power.

II. Materials and Methods

A. Well Water Survey

Various samples were obtained from tube wells, dug wells, rainwater harvesting, and ponds in the rural area of Bangladesh as shown in Fig. 1. The NF process coupled with a bicycle pumping system was examined in Sonargaon and Manikganj. To separate arsenic species such as arsenite and arsenate, samples were preserved by adding nitric acids.

B. Nano Filtration

In this study NF experiments were categorized into three parts. First, rejection characteristics of arsenite and arsenate were investigated by using the cross-flow NF process as shown in Fig. 2. The membrane module was a fiat-sheet type with an effective surface area of 60cm'. The operational conditions of the NF membrane are shown in Table 1. The NF membrane ES 10 used in this experiment is made of aromatic polyamide, and its the nominal salt rejection of ES 10 is 99.6%. The groundwater, to which 200~tg As/L ofarsenite [As (III)] and arsenate [As(V)] is added, was used for feed water. Second, the NF process coupled with the bicycle pumping system was examined by using tube well water in a rural area of Bangladesh. Fig. 3 shows a schematic diagram of the experimental set-up used in Bangladesh. The tube well water, which was used for feed water, was pre-filtrated by microfiltration or directly applied. The NF membranes used in this experiment are ES10 (Nitro Denko Co., Ltd.) and HS5110 (Toyobo Co. Ltd.), of which nominal salt rejection is 99.6% and 94%, respectively, and are made of aromatic polyamide. The membrane module was a spiral-wound type for ES10 and a hollow-fiber type for HS5110. A pump system using a rounded bicycle pedal, with a maximum pressure of 5.0MPa, was used. The range of operational pressure was from 0.3 to 0.7MPa.

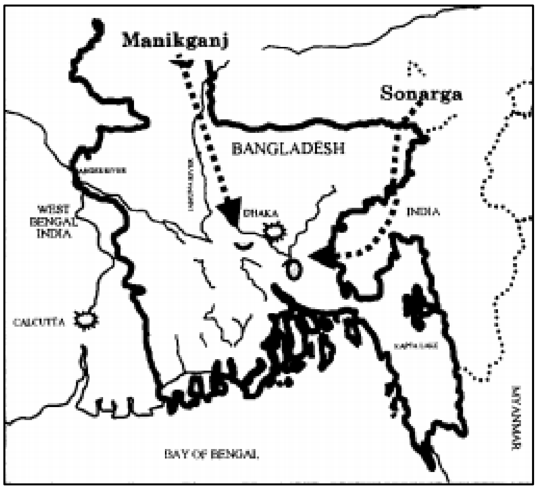

Fig. 1: Sampling Area in Bangladesh

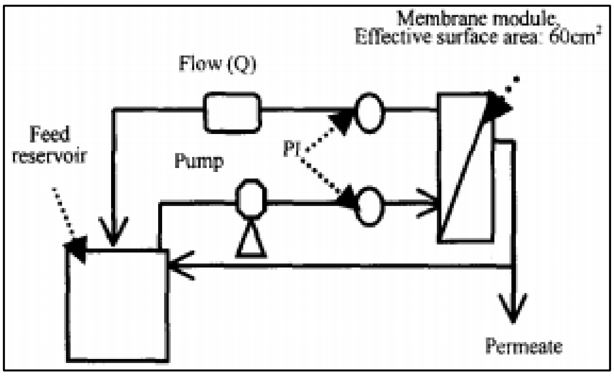

Fig. 2: Schematic Diagram of the Experimental Set-Up of Cross Flow Nano Filtration.

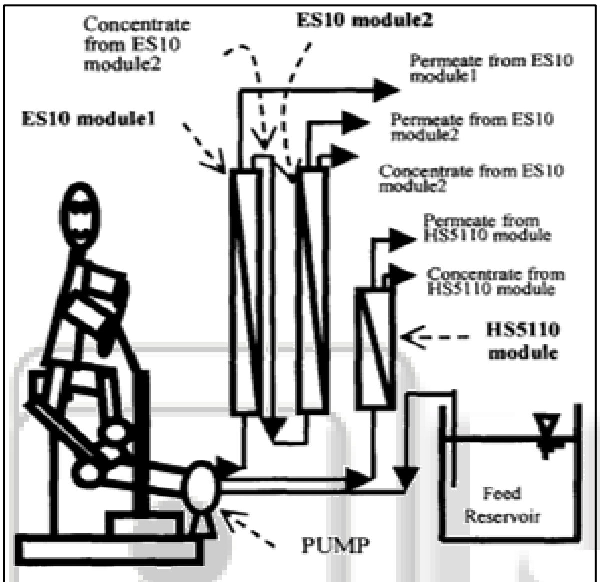

Fig. 3. Schematic diagram of the experimental set-up in Bangladesh based on tube well filtration.

Fig. 3: Schematic Diagram of the Experimental Set-Up in Bangladesh Based on Tube Well Filtration

Table 1
Operational conditions of the cross flow nanofiltration process

	Operational pressure, MPa		
	0.25	0.4	0.6
Circulating flow, L/min		1.8	
Temperature, °C		25	
Flux, $m^3/m^2/d$	0.072	0.144	0.192

Table 1: Operational Condition of the Cross Flow Nano filtration Process

Finally, the RO process coupled with a bicycle pump system was also examined to evaluate whether higher arsenite rejection was available or not. A tight RO membrane, HR3155 (Toyobo Co., Ltd.), was used in this experiment. Its nominal rejection was 99.9% and it was made of cellulose triacetate. The membrane module was a hollowfiber type. Operational pressure was 4MPa. Synthetic groundwater used for feed water, which included 10mg/L of nitric iron [Fe(NO3)3], 0.2mg/L of arsenite [As(liD] and 1 mg/L of arsenate [As(V)].

1) Chemical Analysis

The ion chromatography-the inductively coupled plasma-mass spectrometry (IC/ICP/MS) method was used for the separately analysis of arsenic compounds in different species. Arsenite, dimethyl arsenic acid and arsenate could be separated with the elution liquid of ammonium carbonate, 3mM at pH6.0, using an Excel Park ICS-A23 as a separation column in ion chromatography. Separated arsenic compounds were introduced from an ion chromatograph to IC/ICP/MS using an HP-4500 (Yokogawa Analytical System/Hewlett Packard). Other metals and total arsenic compounds were also analysed by ICP/MS where total arsenic concentration was corrected to avoid 75ARC1 interference. Anions were measured by ion chromatography (IC-7000, Yokogawa Analytical System). Total organic carbon was measured by a TOC5000

III. Design of Bicycle

A bicycle is used for this purpose with the general arrangement as shown in Fig. 1. The type of pump selected for this work is peristaltic pump. A peristaltic pump is a positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing. A rotor in the form of plate with a number of "rollers", "shoes" or "wipers" is attached to the external circumference and connected to the sprocket. As the rollers compress the hose and move away from the inlet a vacuum is created drawing in liquid. The rollers work together to capture liquid between the pinched areas of the tube and move the liquid toward the discharge. (A.S. Akinwonmi, 2012) The front roller leaves the hose, opening the captured area whiles the back roller pushes the liquid out the discharge. This process is called peristalsis and is used in many biological systems such as the gastrointestinal tract. This type of pump is selected for this work because of the following characteristics: because of its wider range of operating speeds, thus efficient at both high and low revolution per minutes (rpm), dry running/self-priming/seal less, creation of high vacuum for suction lift application, smooth passage through the pump thus no checks or obstructions, relatively high discharge pressure.

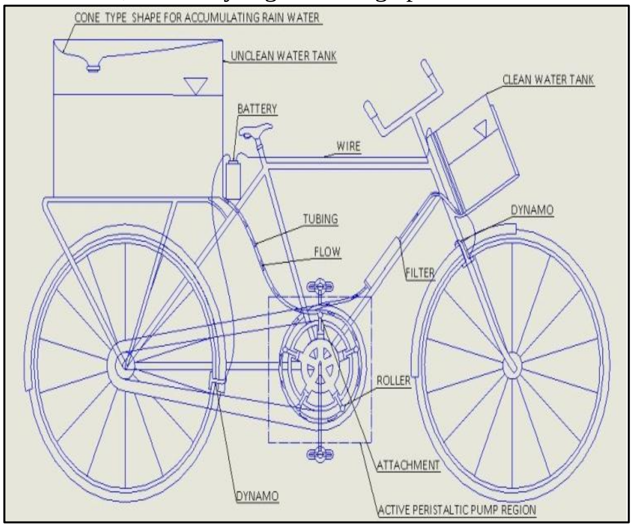

Fig. 1: General Arrangement of the Unit

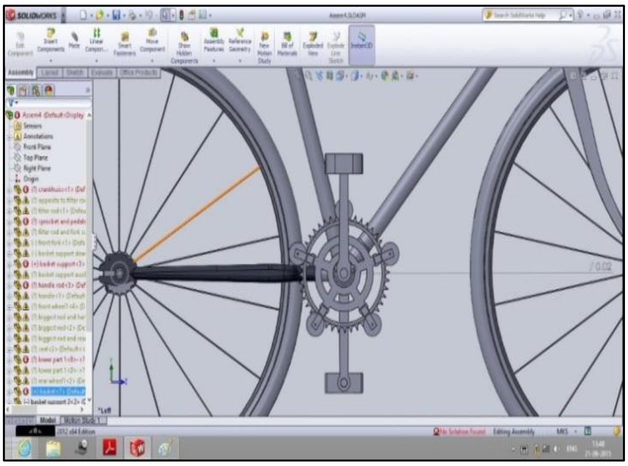

Fig. 2: Pictorial View of the Proposed Design

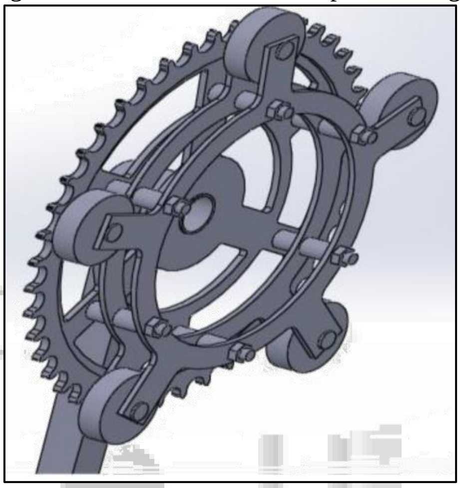

Fig. 3: CAD Model of the Proposed Design

A. *Materials Selection*

Peristaltic pump in the design as shown in Fig. 2 consists of a tube which is squeezed by a set of rollers or shoes to move fluid. By constricting the tube and increasing the low-pressure volume, a vacuum is created to pull the liquid into the tube. The material used for the peristaltic pump is mild steel. This material is used for the pump casing, plates, and shaft. The problem most likely to cause damage to the design is corrosion. For this reason to protect the shaft from corrosion it is subjected to hardening.

IV. RESULTS AND DISCUSSION

The design was focused on all the processes of conception, invention, visualization, calculation, refinement and specification of details that determine the form of the system. The design has gone under force analysis so that its performance criterion will not fail in any sense. The main physical parameters of the design are determined through the appropriate calculations and practical considerations with reasonable assumptions. It is discovered that the design is simple, cheap, efficient and affordable as could be seen from the readily available materials used. Figure 1 shows the setup while figures 2 and 3 show the CAD design and one its components.

V. CONCLUSION

The benefits associated with access to safe drinking water provide a strong argument to increase resource allocations to interventions aimed at further improving the current drinking water situation, as a key entry point for achieving much wider livelihood benefits.

The pedal operated water filtration system is a new system that is useful in developing countries like India to have daily access to safe drinking water all by harnessing the energy of pedal power.

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