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PEDAL POWERED WATER PURIFICATION BY USING R.OMETHOD

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ABSTRACT

This paper is to discover and developed a human powered reverse osmosis. It is a better option for producing potable and pure water for poor, village, and developing place. The all system are determine and human power enough to operate and handle this system, limited amount of clean drinking water will be produce. This device is designed to test the practicality and idea is numerical analysis. In this device uses a bicycle which convert human motion into usable pressure power to run a reverse osmosis filtration system. The flow rate is determined according to given information from the reverse osmosis manufacturer. This is used to calculate the power needed to power such a design and then compared with researched data of available power from humans. It indicated that a human could easily provide enough power to run a reverse osmosis system. The flow rate is used to determine useful this power by considering how produce clean drinking water faster and how much water required person to drink daily. All of the research and results, it was determined that human powered reverse osmosis is not only a viable option, but an incredibly economical and effective means for providing portable water for remote, emergency area and sea basin areas. This system uses a pedal to harness human motion to convert it into useable power to run a reverse osmosis 5 stage filtration system. This was used to calculate the power needed to power such a design and was then compared with researched data of available power from humans.

Keywords: ***Cycling Action, Membrane, Reverse Osmosis, Human motion, Gear Arrangements, Water Purification.***

1. INTRODUCTION

Developing countries around the world face debilitating challenges accessing safe and clean drinking water. Alarming statistics led us to the idea that that we could use a simple mechanism of transportation that is common in these areas, such as the bicycle, to help aid their water and sanitation struggles. Our goal is to design a bicycle attachment to purify and transport water from contaminated sources that is active while the rider is pedaling. This attachment, though not a permanent solution, would be a contribution to the improvement of their quality of life. Our motivation was stemmed from the idea of quickly aiding those less fortunate areas, as well as providing a backup should those regions run into contamination problems within their local wells.The only company that fabricates a bicycle powered water filtration system sold on the market is Nippon Basic Co, Ltd. Nippon was developed after two major Japanese earthquakes the Hanshin Earthquake in 1995 (magnitude of 7.2) and the Chuetsu Earthquake in 2004 (magnitude of 6.8)[1]. The product is essentially made for emergency use, it consists on having a purifying case attached on a rear seat of the bicycle and because of its design the user can ride it to any destination where it may be difficult for other types of transportation to access. The bike is capable of purifying almost any type of water source i.e. ponds, rivers, lakes, bathtub and pools.[2] The device is powerful enough to siphon water from a depth of five meters. Pure water is very much essential to survive but nowadays the water is getting contaminated due to industrialization which leads to many water related diseases. In many developing countries, people walk many miles to reach a source of water that is not necessarily potable. Water can contain dirt, minerals, chemicals and other impurities that make it smell and taste bad. Some of these

contaminants can endanger health, especially when they include microscopic organisms and bacteria that can cause serious illness. Filtering water can help purify water, removing these impurities and making it safe to drink, while often improving its taste. A study conducted by various sources compared different modern methods of water purification- distillation, ultra-violet light, reverse osmosis, solid block activated carbon, granular activated carbon, water softeners, sediment filters, boiling, bottled water, chlorination, ion exchange etc.[3] Among all the above methods mentioned Reverse Osmosis is best suited for issues which were originally designed for mainly two things, they are desalination of brackish water or sea water and reducing very specific chemical contaminants. Reverse Osmosis is needed to remove Fluoride, sodium, total dissolved salts, or chemicals like arsenic, radium and nitrates. In response to such a need, Reverse Osmosis Water Purification by Cycling Action is proposed to produce clean drinking water which uses human power to get pure form of water for drinking.[4] This is quite different than water treatment described above. There are only three scientifically recognized methods of water purification. The equipment is compact, easy to operate, and it is highly energy-efficient, in comparison with distillation and freeze-thawing equipment. RO is an effective method of reducing the concentration of total dissolved solids and many impurities found in water. [5]The most common membrane processes used are the reverse osmosis (RO) and the electro dialysis (ED) used for brackish water desalination, but only RO competes with distillation processes in seawater desalination (Kalogeria).[6]. The process streams that can be recycled are namely, thin slop and process condensate. The effluent generated after removal of the solids. Thin slop contain high TDS, high temperature and contain carbohydrates, organic acids, dead yeast cells etc. which may have an impact on the fermentation process. The process condensate from the evaporator has high temperature, low pH, organic acids etc. This can be treated by RO system and used in the process or for utility operations.[7]

2.1. Reverse Osmosis

Reverse osmosis is a water purification technology that uses a partially permeable membrane to remove ions, molecules and larger particles from drinking water.The reverse Osmosis is the process by which a liquid flows from higher concentration to lower concentration through a semi permeable membrane. Thus it helps in reducing the concentration of the solution and filtering the impurities with less concentration. The membrane is useful in direction of flow of liquids and hence can be made available for the purification. Through this Reverse Osmosis the contaminants in the higher concentrated solutions can be made to flow to the lower concentration solutions.

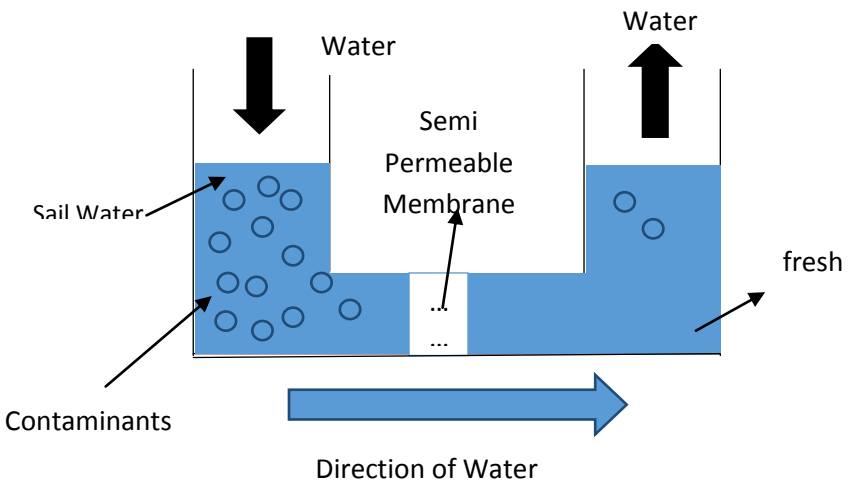

Figure 1: Reverse Osmosis

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Main Components

I. PEDAL
II. FREE WHEELS OF BICYCLE
III. WATER FILTERS
IV. CYCLE CHAIN
V. PULLEY
VI. PUMP

I. PEDAL

The bicycle pedal is the part of a bicycle that the rider pushes with their foot to propel the bicycle. It provides the connection between the cyclist's foot or shoe and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels. Pedals usually consist of a spindle that threads into the end of the crank and a body, on which the foot rests or is attached, that is free to rotate on bearings with respect to the spindle. Pedals were initially attached to cranks connecting directly to the driven (usually front) wheel. The safety bicycle, as it is known today, came into being when the pedals were attached to a crank driving a sprocket that transmitted power to the driven wheel by means of a roller chain.

Figure 2: Pedal

II. FREE WHEELS OF BICYCLE

In mechanical or automotive engineering, freewheel or overrunning clutch is a device in a transmission that disengages the drive shaft from the driven shaft when the driven shaft rotates faster than the driveshaft. An overdrive is sometimes mistakenly called a free wheel, but is otherwise unrelated. The condition of a driven shaft spinning faster than its driveshaft exists in most bicycles when the rider holds his or her feet still, no longer pushing the pedals. In a fixed-gear bicycle, without a free wheel, the rear wheel would drive the pedals around. The simplest freewheel device consists of two saw-toothed, spring-loaded discs pressing against each other with the toothed sides together, somewhat like a ratchet. Rotating in one direction, the saw teeth of the drive disc lock with the teeth of the driven disc, making it rotate at the same speed. If the drive disc slows down or stops rotating, the teeth of the driven disc slip over the drive disc teeth and continue rotating, producing a characteristic clicking sound proportionate to the speed difference of the driven gear relative to that of the (slower) driving gear.[8]

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III. WATER FILTERS

A water filter removes impurities by lowering contamination of water using a fine physical barrier, a chemical process, or a biological process. Filters cleanse water to different extents for purposes such as providing agricultural irrigation, accessible drinking water, public and private aquaria, and the safe use of ponds and swimming pools.[8]

Figure 3: Water Filter

IV. CYCLE CHAIN

A bicycle chain is a roller chain that transfers power from the pedals to the drive-wheel of a bicycle, thus propelling it. Most bicycle chains are made from plain carbon or alloy steel, but some are nickel-plated to prevent rust, or simply for aesthetic.[9]

Figure 4: Cycle Chain

V. PUMP

The purpose of the reverse osmosis booster pump is to increase water pressure going into the RO unit. Reverse osmosis is a pressure-driven process. It plugs into a standard wall outlet and converts to the voltage (most commonly 24 volts) required by the pump. A gear pump uses the meshing of gears to pump fluid by displacement.

Figure 5: Pump

VI. PULLEY

Pulleys are a type of simple machine designed to reverse the direction and reduce the amount of the force required to lift or move an object. Although pulleys were in use much earlier, Simon Stevin first enunciated their principles of action in about 1610. A pulley system is simply one or more pulleys connected by rope or string. In order to analyze a pulley system, the knowledge of a few physical concepts is necessary. Mass is the measure of the amount of substance of an object. In the metric system, mass is measured in kilograms (kg).[10]

Figure 6: Pulley

2.1. METHODOLOGY

A bicycle is used for the purification purpose with the general arrangement. Than the R.O pump or motor head selected for this work is water are pressurized. A motor head is a positive displacement pump used for pumping water. The fluid is contained within a flexible tube fitted inside a circular motor head. A rotor in the form of wheel with a number of "rollers", "Bearing" and "shoes" is attached to the external circumference and connected to the cycle frame. As the rollers compress rotate and move away from the inlet a vacuum is created drawing in liquid. The rollers work together to capture water between pinched areas of the tube and move the liquid toward the discharge. Both roller like the first front roller leaves the hose, and opening the captured area whiles the back roller pushes the water out the discharge. [11]

Water are purified in different stages such as-The dirty or salt water is stored in the tank and its dirty water is taken and purified by the help of pedal pump and purification system through. The pedal is operated though the human so that the motor head pump operates because it is both are connected to each other. The pump wills the dirty water from the tank to the first filter. Then the filtered water will be sent through the second another filter through the pipe automatically. The first filter is the sedimentation filter and the second filter is the salt filter in which salt from the water is removed and purified. After the filtering process takes place the filtered water is collected in another tank. Here we use a pedal and chain drive system to operate the motor head pump to pump the water from low level to the high level filter for the filtering process.

Stage1: First filter like sediment filter used, and it removes sediments particles and improve taste and this filter removes the water impurities in size is greater than or equal to 5 micron or 4 micron.

Stage2: This stage activated carbon filter used and it removes organic and inorganic materials with in size greater than or equal to 5micron.

Stage3: Carbon block filter is used for remove the chloride and organic compounds like impurities. It is the end of the pre filter stage it is also removes the impurities which are greater than 5 micron [15].

Stage4: The heart of the purification process. In this stage R.O filter membranes used, by using greater than 5 microfiltration it removes all particles down to 0.001 micron in size and produce completely pure drinking water.

Stage5: Water passes through an anti-micro-bio filter cartridge to prevent unpleasant odors, tastes and micro-organisms.

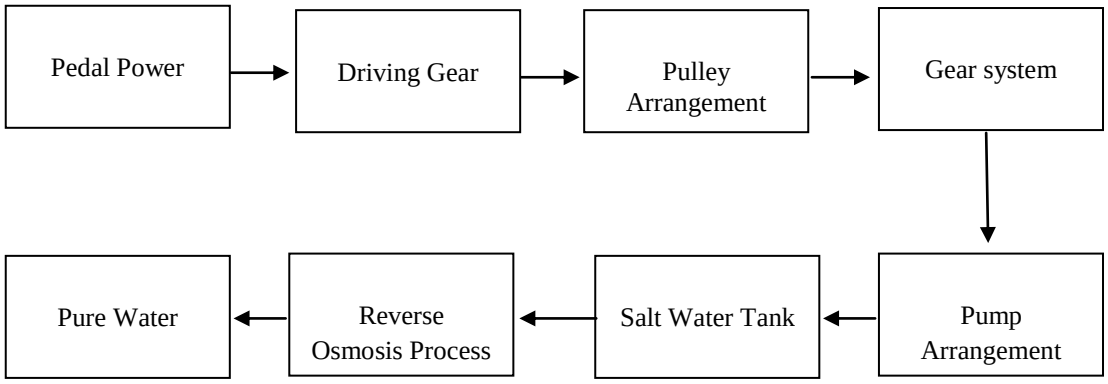

Figure 2: Process Flow Chart

There are only three major principles on which our working model generally works:

1. Power transmission through chain drive mechanism.
2. Bernoulli's equation.
3. Power transmission through pulley belt arrangement.

Power Transmission through Chain Drive:

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of avehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system.[10]

Bernoulli's principle:

In fluid dynamics, Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. The principle is named after Daniel Bernoulli who published it in his book Hydrodynamic in 1738. Bernoulli's principle can be applied to various types of fluid flow, resulting in various forms of Bernoulli's equation; there are different forms of Bernoulli's equation for different types of flow. The simple form of Bernoulli's equation is valid for incompressible flows (e.g. most liquid flows and gases moving at low Mach number). More advanced forms may be applied to compressible flows at higher Mach numbers (see the derivations of the Bernoulli equation).

***Power Transmission through pulley belt arrangement*:**

Belts are the cheapest utility of power transmission between shafts that may not be axially aligned. Power transmission is achieved by specially designed pulley and belt. They run smoothly and with little noise, and cushion motor and bearings against load changes. This arrangement is made for power transmission and to reduce rpm as per requirements.[11]

2.2. Design Analysis and Calculations

The system design being by assessing all of the physical variables of the pump head, diameter (D) of 0.25m, tubing diameter (d) of 0.01m, tubing length (L), friction due to pedal, friction where the rollers connect to the arms or frames and rolling friction. Dependent variables like, which include flow rate (Q), rotating speed (N) and required power (P). These include tubing length, and roller diameter. Rolling friction and friction in the pedals were estimated to be negligible and were not considered in this design. To establish an analytical model using these parameters, it is necessary to consider the relation among the various parameters. [12]

Pump head dimension is 10×10×15 cm, and 43 gram weight. Ideal pressure for operating an R.O system is 60PSI, pressure below 40PSI is generally considered insufficient and should be boosted using a pressure booster pump. According to WHO in R.O process required that a high pressure be exerted on the concentration side of the membrane usually 2 to 17 bar (30 to 250 PSI) for fresh and brackish water and 40 to 82 bar (600 to 1200 PSI) for seawater , which has around 27 bar (390 PSI) natural osmotic pressure that must be overcome [13]

Table 1:physical parameters

Parameters	Values
Pump Head dia. (m)	0.30
Tube dia. (m)	0.02
Tubing length(m)	2
Human average pedaling speed(rpm)	30 – 40
Rotor speed(rp)	105-135

Table 2: Calculated Data

Pedal speed by human(N)	Rotor speed (n)	Discharge (m^3/s)	Power (P) =T×ω (Watt)
30	90	4.989×10^{-4}	8.9
32	96	5.043×10^{-4}	12.17
34	102	5.207×10^{-4}	12.72
36	108	5.372×10^{-4}	13.27
38	114	5.536×10^{-4}	13.82
40	120	5.701×10^{-4}	14.37

Trial 1:- Sample water: Tank water

This sample water is taken into the bore well water supplies in dirty tank and this dirty tank water is measured, before R.O system supply water is 500 PPM qualities and after the filtered water is 160 PPM.

Table3: Water Quality (PPM) And Quantity (liter)

Water Type	TDS value (PPM)	Quantity (liter)
Water before filtered from the tank	500	2
Water pass to the RO membrane	250	1.7
Water after filtered (Post Carbon filter)	140	1.5
Drain water	169	0.5

Trial 2:-Sample water: Bore well water

This sample water is taken into the bore well and direct supply to the R.O system this water is 445 PPM qualities and after the filtered water is 160 PPM quality water achieved.

Table4: Water Quality and Quantity

Water Type	TDS value (PPM)	Quantity (liter)
Water before filtered from the tank	445	2
Water pass to the RO membrane	201	1.7
Water after filtered (Post Carbon filter)	94	1.5
Drain water	151	0.5

Trial 3:-Sample water: collegewater (Buddha Institute of Technology Gorakhpur)

This sample water is taken into the bore well pipe in Buddha Institute of Technology Gida Gorakhpur and direct supply to the R.O system this water is 275 PPM qualities and after the filtered water is 39 PPM quality of water achieved.

Table5: Water Quality and Quantity

Water Type	TDS value (PPM)	Quantity (liter)
Water before filtered from the tank	275	2
Water pass to the RO membrane	210	1.9
Water after filtered (Post Carbon filter)	45	1.6
Drain water	115	0.4

Trial 4:-Sample water: Rapti River near Rajghat

This sample water is taken into the Rapti River nearby Rajghat Gorakhpur and supply to the R.O system this water is 746 PPM qualities and after the filtered water is 236 PPM quality of water achieved.

Table6: Water Quality and Quantity

Water Type	TDS value (PPM)	Quantity (liter)
Water before filtered from the tank	746	2
Water pass to the RO membrane	295	1.6
Water after filtered (Post Carbon filter)	210	1.5
Drain Water	498	1.8

Trial 5:-Sample water: Bank of RaptiRiver

This sample water is taken into the Bank of Rapti River Gorakhpur and supply to the R.O system this water is 1000 PPM qualities and after the filtered water is 349 PPM quality of water achieved.

Table7: Water Quality and Quantity

Water Type	TDS value (PPM)	Quantity (liter)
Water before filtered from the tank	1000	2
Water pass to the RO membrane	604	1.4
Water after filtered (Post Carbon filter)	302	0.8
Drain water	699	1.15

$$Q = Vtotal \times (rotational\ speed\ per\ minute)$$al speed per minute)

the roller = Area of the tube (cross-section area) × (circumference of pump head)

$$v = \left(\left(\frac{\pi}{4}\right) \times d^2\right) \times (\pi \times D))$$

$$v = ((\Pi/4) \times d2) \times (\Pi \times D)$$

$$v = 7.1\times10^{-5}$$

$$Q = Area \times Velocity$$locity

$$Q = 4.99\times 10^{-4}$$

The force needed by the flexible tube choosing thus TygonTMXL-60 to retract after compression is 150 N therefore the force that will act on the rollers, F = 150 N. Also assuming a friction coefficient of 0.3 [6]

$$Power\ deliver\ to\ the\ pump\ (P) = T \times \omega$$P)=T×ω

total=T1+T2=2F1r1+F1r1=2μNr1+μNr2

$$T\ total = (2 \times 0.3 \times 0.125) + (0.3 \times 35 \times 0.005)$$

$$T = 3.5Nm$$

$$P = 8.9watt$$

2.3. RESULTS

The design was focused on all the processes of conception, invention, visualisation, calculation, refinement and specification of details that determine the form of the product. 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. It can be seen from the design analysis that the rate of discharge per occlusion is considered reasonable. The power required to drive the pump is 6.2902W, 2.878 $\times10^{-4}$ discharge for pedal speed 35 rpm which are all good and reliable.

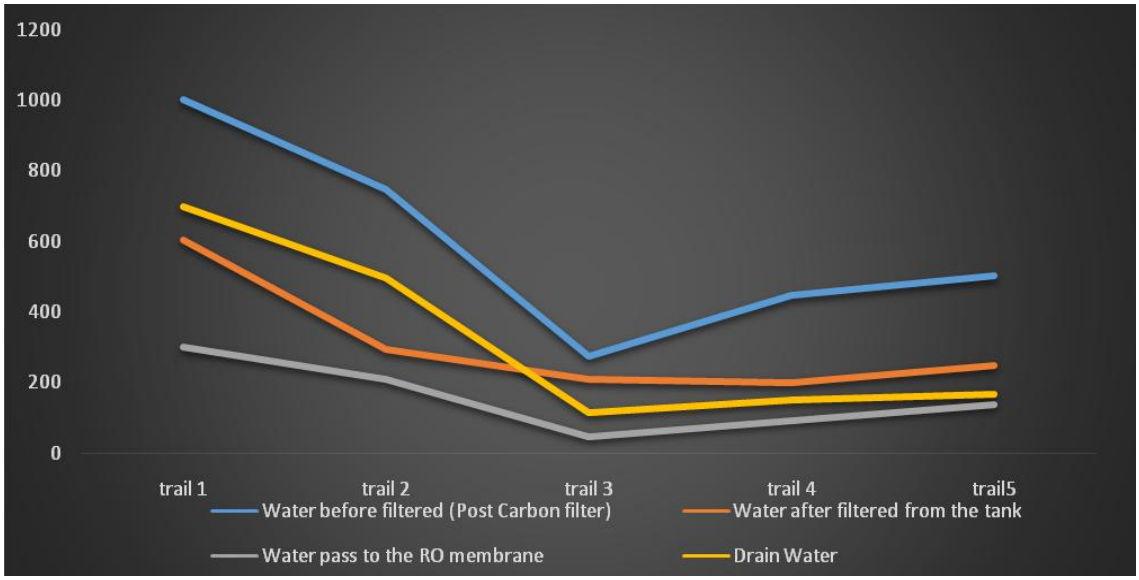

Figure 7: Water purification at different stage

The above graph isrepresenting the water purification at different stages. Firstly graph is move down ward mean purification is work than at a certain point graph is move upward means this upward is represent the drain water and the drain water quality (PPM) is more than the purified water quality. X axis is water purification stage and the y axis is water quality in PPM represent.

3. CONCLUSIONS

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 pure drinking water situation, as a key entry point for achieving much wider livelihood benefits. The pedal powered purified water supply system is utilizes simple inventions and puts them all together to help villages in developing countries like Indian villages, and another undeveloped area access to safe drinking water all by harnessing the energy of pedal power.

4. Future Scope

The future scope includes the structure of the model and the type of motor head pump to get higher pressure generated. The RO filters can be made combinations with multiple of R.O filters to achieve high quality of pure water, by increasing the speed of cycling action higher rate of water flow can be generated. The model can be redesigned in to movable model from stationary model by using bicycle system in which motor head pump and filters can be attached using suitable mechanism, and it can be even used as a travelling device from one place to another place and hence pure water can be collected in separate tank by the time and deliver one place to another place.

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