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PEDAL POWER WATER PURIFICATION BY USING REVERSE OSMOSIS

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ABSTRACT

The pedal powered water purification by R.O is a mechanical developed device which is used to purify the dirty water source with the help of mechanical and pressure energy. 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. 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, 2.878×10^{-4} discharge and the efficiency gives 95% which are all good and reliable.

Keywords: *Cycling Action, Membrane, Reverse Osmosis, Human motion.*

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

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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. The term water purification refers to a process, which selectively extracts pure water from an impure solution, leaving all kinds of impurities behind, regardless of their source or their nature. This is quite different than water treatment described above. There are only three scientifically recognized methods of water purification. These are: Distillation, freeze-thawing, and reverse osmosis (RO), reverse osmosis offers the most practical and economical approach to water purification. Each Sawyer filter is certified for ABSOLUTE microns; that means there is no pore size larger than 0.1 or 0.02 micron in size. This makes it impossible for harmful bacteria, protozoa, or cysts like E. coli,

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

Giardia, Vibrio cholera and Salmonella typhus (which cause Cholera and Typhoid) to pass through the Sawyer PointONE™ biological filter. At 7 log (99.99999%) the filter attains the highest level of filtration available today.[4]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]. In case of grain based distillery the treatment given is by way of DWGS separation, incineration and biomethanation. 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]

Reverse Osmosis

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.[4]

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. [8]

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

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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 [9].

Stage4: The heart of the purification process R.O filter membranes used, by using greaterthan 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.

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 $\times 10^{-4}$ discharge for pedal speed 35 rpm and the efficiency gives 95% which are all good and reliable.

The above shows the power verses pedal speed. The minimum power is 6 watt is supplied at 35 rpm and maximum power is 12 watt supple at 45 rpm. The average human speed is 35 to 45 rpm and this rpm according power is varies.

The above shows that the represent of 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.

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ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

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. Before the filtration water is boiling this result the water PPM is reduce (i.e water quality before boiling 450PPM after boiling water is 278 PPM).

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. [10]

Pump head dimension is 10×10×15 cm, and 43 gram weight. Ideal pressure for operating an R.O system is 60 PSI, 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 [11]

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.as compair to other purification this system is more reliable more efficient. 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.

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National Conference on Futuristics in Mechanical Engineering
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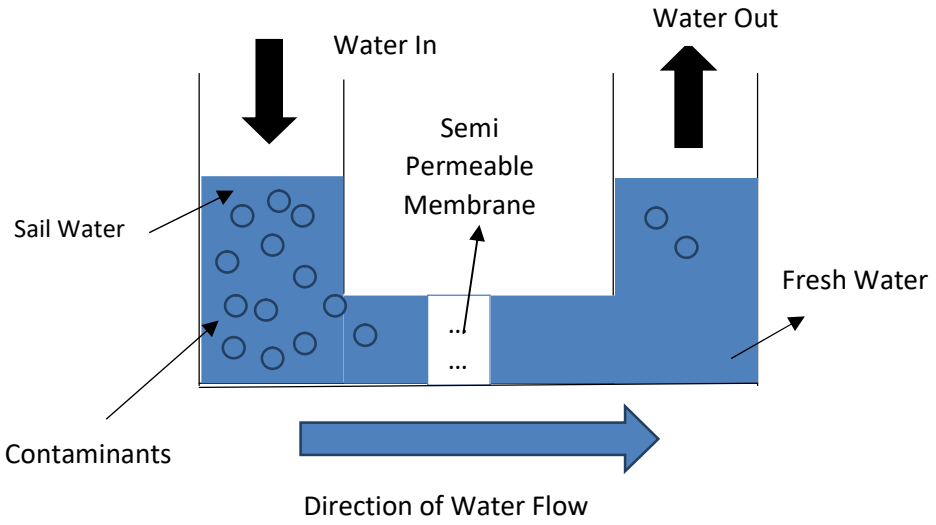

Figure 1: *Reverse Osmosis*Methodology

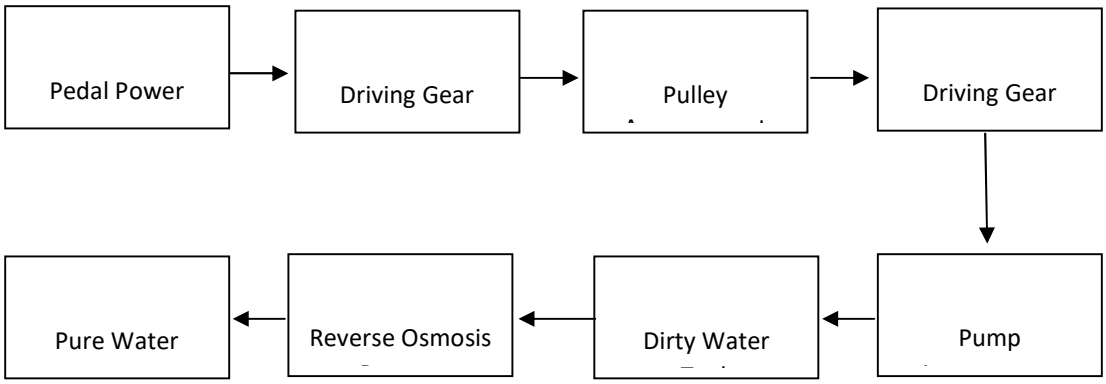

Figure 2: *Process Flow Chart*Results and Discussion

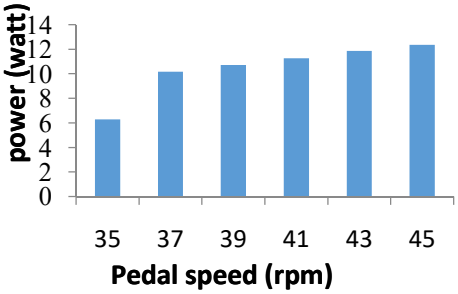

Figure 3: *Plot Power Verses Pedal Speed*

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

The above shows the power verses pedal speed. The minimum power is 6 watt is supplied at 35 rpm and maximum power is 12 watt supple at 45 rpm. The average human speed is 35 to 45 rpm and this rpm according power is varies.

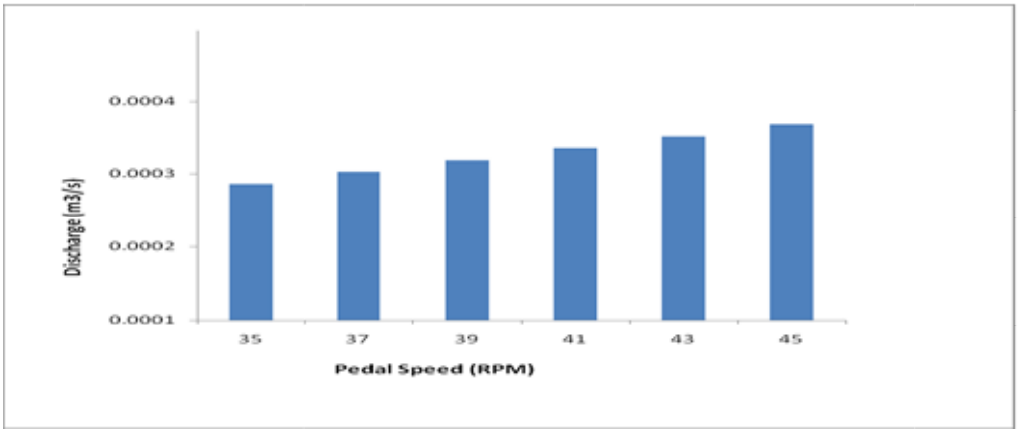

Figure 4: *Plot Discharge Verses Pedal Speed*

This graph is plotted discharge verses pedal speed. The minimum discharge 2.878×10^{-4} m3/s supplied at 35 rpm and maximum discharge 3.70114×10^{-4} is supple at 45 rpm. The average human speed is 35 to 45 rpm and this rpm according power is varies.

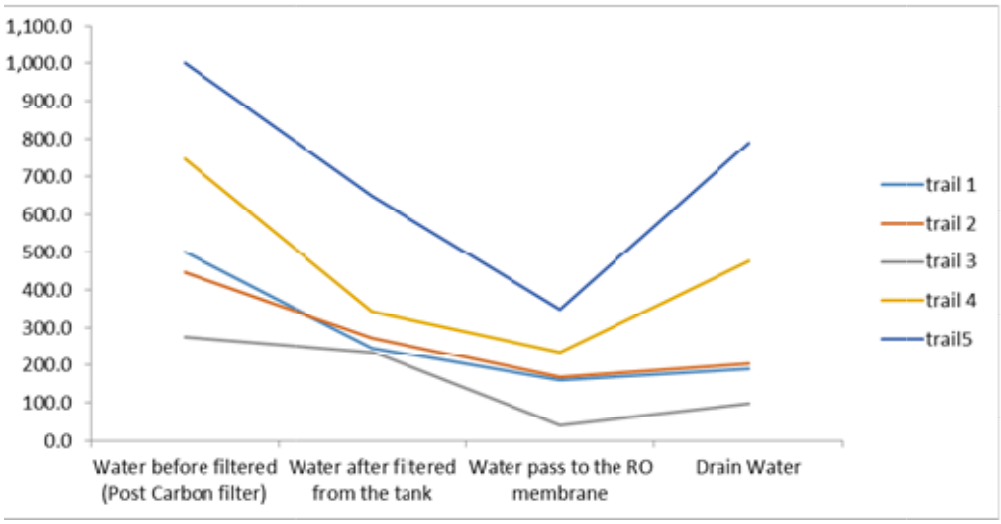

Figure 5: *water purification at different stage*

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

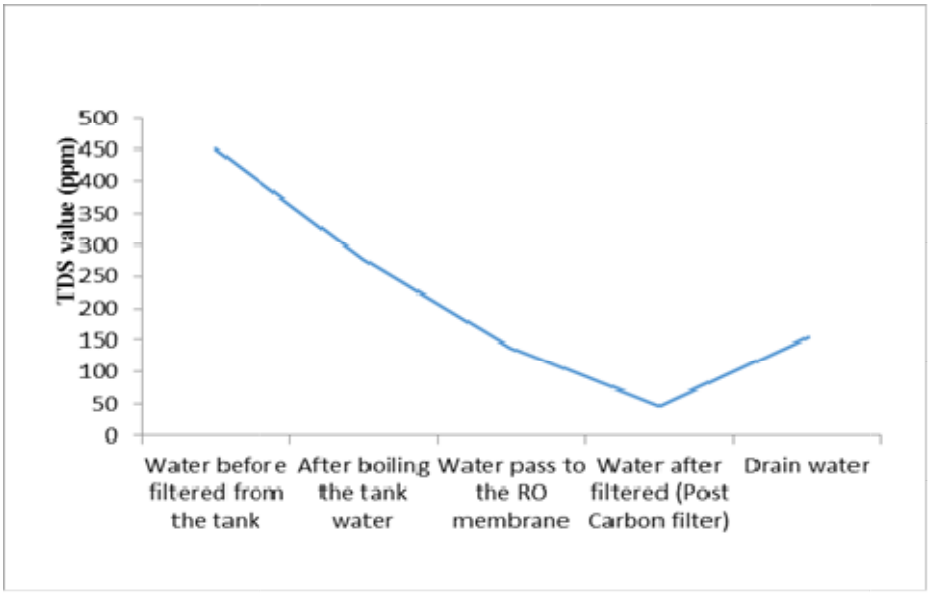

Figure 6: *Boiled water purification at different stage*

Table 1: *physical parameters*

Parameters	**Values**
Pump Head dia. (m)	0.25
Tube dia. (m)	0.01
Tubing length(m)	2
Human average pedaling speed(rpm)	35 – 45
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)**
35	105	2.878×10^{-4}	6.2902
37	111	3.04312×10^{-4}	10.1709
39	117	3.20762×10^{-4}	10.7206
41	123	3.372114×10^{-4}	11.2704
43	129	3.536608×10^{-4}	11.8202
45	135	3.70114×10^{-4}	12.37

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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	267	1.77
Water after filtered (Post Carbon filter)	160	1.5
Drain water	189	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	223	1.77
Water after filtered (Post Carbon filter)	117	1.5
Drain water	117	0.5

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

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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	236	1.9
Water after filtered (Post Carbon filter)	39	1.6
Drain water	94	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.

Table 6: 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	342	1.6
Water after filtered (Post Carbon filter)	236	1.55
Drain Water	476	1.845

Trial 5:-Sample water: Bank of Rapti River

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)**

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National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

Water before filtered from the tank	1000	2
Water pass to the RO membrane	650	1.4
Water after filtered (Post Carbon filter)	349	0.85
Drain water	789	1.15

Trial 6:-Sample water: Boiling Water A 100 ˚C

This sample water is taken into the tank and boiling at 100 ˚C. Before the boiling water is 450 PPM and after the boiling water is 278 PPM water achieved this water are supply to the R.O system and after the filtered water is 47 PPM quality of water achieved.

Table6: Water Quality and Quantity

Water Type	**TDS value (PPM)**	**Quantity (liter)**
Water before filtered from the tank	450	2
After boiling the tank water	278	1.85
Water pass to the RO membrane	139	1.62
Water after filtered (Post Carbon filter)	47	1.3
Drain water	155	0.7

Discharge

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

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

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

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

$v = 6.168 \times 10^{-5}$

$$Q = Area \times Velocity$$

ISSN 2349-9368(Online);EAPJMER/ISSN.2454-2962/2016;

$$Q = A \times V$$

$Q = 2.878 \times 10^{-4}$

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]

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

$$T\ total = T1 + T2 = 2F1r1 + F1r1 = 2\mu Nr1 + \mu Nr2$$

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

$$T = 2.625Nm$$

$$P = 6.2902Watt$$

where, m_i = Initial mass and m_f =Final mass