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2. Rainwater Management using Treadle Pump

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Abstract:

In old days, there were plenty of open ground, kuccha roads, and open fields were available for receiving rain. Due to this, the rainwater gets easily absorbed into the ground, and the management of rainwater was not a big problem. However, as the cities and villages becomes more developed, these open fields, grounds are covered with concrete and the rainwater cannot get absorbed and collects on the roads, open grounds etc.

But this problem can be solved by storing the rainwater in underground tanks and it is used later for irrigation or gardening using Treadle pump. Treadle pump is a foot operated pump and consumes no electrical power. The rainwater management solution is discussed in the present work, by storing rainwater in the underground tanks and then pumping with treadle pump, without consumption of any electric power.

Keywords: Rainwater harvesting, rainwater management, treadle pump.

2.1 Introduction:

Treadle pump is a type of suction pump, which is powered by human. It is a type of reciprocating pump. It is similar to the hand pump used during old days in homes, which have a piston-cylinder type suction pump and was operated using lever provided on top, which moves the piston up and down. Treadle pump also contain that type of cylinder piston suction pump, but it is operated using foot.

It has two cylinders instead of one. This ensures continuous supply of water during operation. It has a lever, which is connected to each piston in cylinder. With suitable mechanism, when the levers moved up and down, by foot, they press the piston of pump, alternatively. They are moved by pressing treadle lever.

It is mainly used for farming of small land. The main advantage of treadle pump is, by using it; the farmers have to not rely on rainwater.

They can set this pump near any well, which stores ground water. It can be used to lift water from height of 5-7 meters and can deliver water at rate of seven cubic meters to nine cubic meters per hour. It can also be used to lift water from lakes or rivers for farming at low cost. Mostly, Treadle pump is used by those farmers, which have small area of land for irrigation.

Govt. of India is also reviving ponds under Gurujal Project. Under this project, all the existing ponds will be revived to meet the water demands of peoples, during off rain season.

In starting treadle pump was operated with one leg. However, after some improvement in design, treadle pump with two levers is introduced. [1]. since, then many improvements in the design of treadle pump has been done.
Treadle pump got its name through its operating levers, which are like treadle. Like, treadle is the machine, which is used to do exercise; its lever is also moved in same way up and down. The length of lever can be increased or decreased according to the load. With the two-cylinder treadle pump, the output supply of water is continuous.

When one cylinder is discharging the water, other is sucking the water. And after that, this cycle repeats again and again. With the advancements in the design of treadle pump, its operation become much easier. Moreover, due to standardizing its design, its production time is improved. The weight of treadle pump is around 5-8 Kg, and dimensions are up to 1.5-2 meter length and 0.5- 0.75 meter width. The pump can be fixed to the base concrete foundation very easily using four struts and nuts.

After fixing to the base, it can be used to lift stored water from height of 5-7 meters very easily. Also, this water can be delivered at very long distance up to 9-10 meters very easily.

Figure.2.1 Farmer Using Basic Treadle Pump

2.2 Methodology:

Rainwater is the water received during rainfall. In old days, this Rain Water Management was not a big problem due to the availability of plenty of open ground, kuccha roads, open fields etc.

In addition, Rainwater gets easily absorbed into the ground, which recharge the ground water table, and no accumulation of rainwater in open areas for long time.

But as the cities and villages becomes more and more developed, these open fields, grounds and roads are covered with thick material like cement concrete, bitumen concrete layer and this thick layer does not allow water to pass through them.

Due to this the rain water can't get absorbed and will accumulated on the roads, open grounds etc. and make its way out through the city drainage system. Due to sudden increase in the water amount, these systems get overloaded and this further creates problem.

Figure.2.2 Rainwater logging in open area

Figure.2.3 Rainwater logging on roads

Figure.2.4 Rainwater logging at football field

Figure.2.5 Rainwater logging on highways

One way to solve this is to store the rainwater in tanks etc., but to recover that water we also have to spend energy. This problem can be solved using Treadle pump.

The rainwater of the rooftops, open ground, open field can be stored in the underground water storage tanks, for future use. And this stored water can be conveniently extracted using treadle pump. This treadle pump can be easily installed near the storage tanks on flat solid foundation using struts and nuts. And connected to the nearby storage tank.

Figure.2.6 Under-ground water Storage Tank

Figure.2.7 Water Storage tank at University Campus

In open public parks, the people who visit park can operate this for watering the plants in park, and contribute to the development of park.

In open fields, the children who used to play in ground can water the grass in the ground using this pump.

Along with this, it can be used in homes also, and can be used for gardening purposes using stored rooftop rainwater.

In open areas like university, college, school playground, this pump can be used effectively for watering purposes.

There are seamless uses of the treadle pump in the management of rainwater.

If someone wants to monitor the usage of treadle pump, then the smart monitoring system can also be integrated with this pump. One such system is as second part of this project, which includes smart Treadle pump monitoring system.

This includes the integration of Internet of Things with the monitoring system. A Wi-Fi based microcontroller is used for remote monitoring of the pump. Since in university campus Wi-Fi is available, this type of microcontroller is used. However, in open areas like public park, open fields, or during irrigation GPRS based microcontroller can be used for remote monitoring.

Along with the Wi-Fi based microcontroller, a rotary type flow measurement sensor is used, which is compact and offer much high accuracy compared to other sensor.

A mobile application is also developed for android-based smart phones to monitor the usage of pump easily for the end user.

Figure.2.8 Treadle Pump Installed on Concrete Base

2.2.1 Working of Treadle Pump:

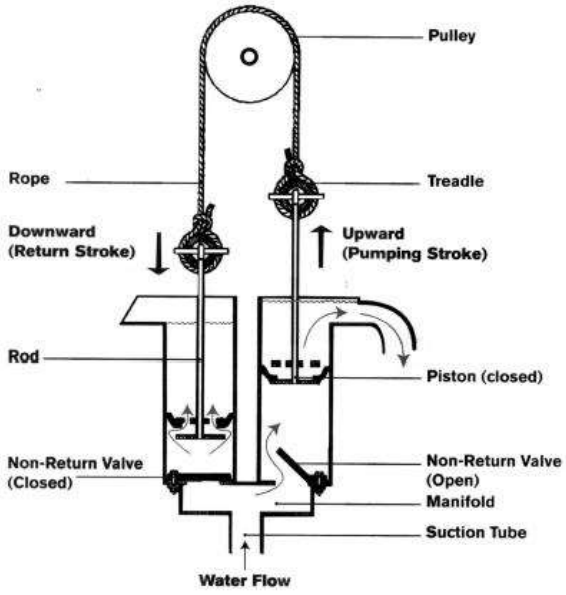

Figure.2.9 Working of Treadle Pump

The working of the treadle pump can be easily understood by above diagram. As already discussed, it has two cylinders with piston to create suction. The use of two cylinders ensures the continuity in the output supply. Each cylinder contain two non-return valve, one at inlet and other at outlet. Also, both pistons are coupled with each other via rope [3].

Starting from the right side cylinder in the given figure 2.9, the piston in the right side is moving upward direction. And because pistons in both cylinder are coupled, the piston in the left side cylinder will move downward. Now, during the upward motion of the piston, the non-return valve on the inlet of cylinder will open, and the other, at outlet will remain close. Due to this, the pressure below the piston will reduces below atmospheric pressure, and water from the collection tank or source will rush to the region of negative pressure through inlet pipe. During this, the piston will suck water from the collection tank.

Now, in the next stage, the piston in right cylinder will move downward. During this stage, the non-return valve at the inlet will close and the other at outlet will open up. When piston is forced to move downward by the user, the pressure below the piston will increases above the atmospheric pressure, and due to this, the water collected below the piston will rush to the region above the piston through outlet non-return valve. At this stage, the water is still in the cylinder but it is shifted from below the piston to above the piston.

In next stage, the cycle is repeated and the piston will now moves upward, and create suction from the source. Now, the upper region is filled with already collected water, so when the piston moves upward it pushes the water out to the delivery pipe, which can be used by user to fulfil his need. This cycle repeated continuously until the pump is running. Same processes also takes place in the second cylinder.

To enable the remote monitoring of the pump, smart flow measurement device can be attached to the delivery pipe, which is designed and fabricated as other project by me. This smart flow measurement device uses Internet of things to link the pump with the user's smart phone. A Wi-Fi based micro-controller ESP8266 is used in this along with a rotary type flow measurement sensor and a cloud server.

Specification of Treadle Pump used [4]

Parameter	Value
Max Flow Rate	5000 lph
Suction Head	5-6mtrs
Delivery Head	7-8 mtrs
Weighting Capacity	12 kgs
Storage Tank Capacity	500 Ltr

2.3 Result and Discussion:

A treadle pump is bought and installed in the university campus, after some modifications in the design. It is now used for gardening purposes, using the stored rainwater. The pump is installed on a strong concrete base with struts and bolts.

The pump can deliver 4000- 5000 lph, and is used to deliver water up to 10 meter away from the underground water storage tank and treadle pump. The installation cost of the treadle pump is around ₹5000. Anybody can use this pump for watering purposes. Since power and internet through Wi-Fi is available in the university campus, smart flow measurement device is attached to the pump, which gives daily water usage data over the internet using Internet of Things, to the android mobile application developed for the monitoring.

Apart from this, this treadle pump can be installed in open areas like playgrounds, Public Park, school, college or university campus for utilizing the stored rainwater for useful purposes. The rainwater harvesting will become much more useful and easy for the people, with this treadle pump. There may be other uses of the treadle pump, which are limited by the imagination of the end user.

Figure.2.10 Underground Rainwater Storage Tank

Figure.2.11 Watering to Plants

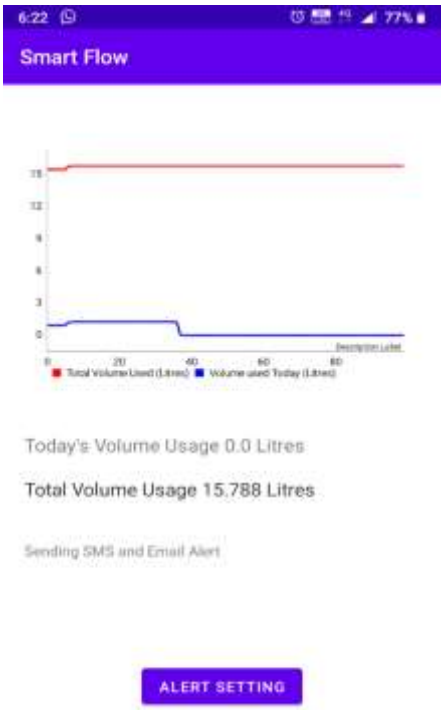

Figure. 2.12 Smart Monitoring app **Figure.2.13 Person Using Treadle Pump in University Campus**

2.4 Image Source

Figure 1- https://www.engineeringforchange.org/wp-content/uploads/2017/07/iDE-Treadle-pump-main-400x400.png
Figure 2- https://cdn.frontdoorhome.com/ahs/blog/prod/static/cs/ahs/image/water-in-yard.jpg
Figure 3- https://static.toiimg.com/thumb/msid-78331825,width-1200,height-900,resizemode-4/.jpg
Figure 4- https://www.lzbearfacts.com/wp-content/uploads/2014/09/DSC_1434-1280x857.jpg
Figure 5- https://s.w-x.co/util/image/w/in-gurugram_0.jpg?crop=16:9&width=480&format=pjpg&auto=webp&quality=60
Figure 6- https://thumbs.dreamstime.com/z/underground-rainwater-storage-tanks-two-plastic-placed-below-ground-harvesting-126661075.jpg

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