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Sustainable Wastewater Treatment and Utilization: A Conceptual Innovative Recycling Solution System for Water Resource Recovery

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Abstract: The global demand for drinking water is increasing day by day. Different methods are used for desalination of water, which can help in the conservation of resources, such as seawater, highly saline, or treated water underground reservoirs. Polluted water can be treated by the utilization of different advanced techniques. In this study, wastewater mixed canal water has been taken into consideration for the utilization of humans and agriculture use as well. A two-stage conceptual methodology has been proposed to deal with the water conservation and utilization process. In the first phase, power has been produced using a Belgian vortex turbine, which is a safe, efficient, and eco-friendly technology working without disturbing waterways. The power produced by the vortex machine will be utilized to operate the water treatment plant to obtain clean water for utilization in the second phase. Since enough energy is produced, and its availability to the water head level base is a natural resource, this energy can be used to fulfill daily water requirements by maximizing the energy-driven treatment process as per WHO Guidelines. Water quality can be monitored at regular intervals, depending upon the selection and installation of a treatment plant. An increase in efficiency comes from nearly exponential patterns depending on water velocity and availability. This technique will not only help in the production of clean water but will also help in the conservation of groundwater resources and the efficient utilization of wastewater.

Keywords: sustainability; water reuse; water management; resource recovery

1. Introduction

Presently, water shortage is a worldwide issue; almost half of the world's population suffers from water shortages [1]. One of the possible solutions to this problem is to purify alternate water sources, such as seawater, brackish water, processed water, or underground water reservoirs [2,3]. Other conventional methods include reverse osmosis. The cost of water purification technology and increase energy is the major issue; on the other hand, given the increasing demand for purifying water, there must be some sustainable and suitable methods [4]. To resolve this problem, worldwide research has been undertaken based on thermal and localized photo-thermal heating for the water purification process; solar water purification technology has also always been a research hotspot worldwide, and many variations have been made recently [5–9]. Optical nanotechnology is a method of purifying water with the support of sunlight and is suitable for transporting it to remote areas. This process depends on a membrane covered with broadband nanoparticles that absorb light; when exposed to sunlight, it generates localized heat. Salty light flows along the bright side of the membrane [3,4,7]. Different techniques are applied to treat water, these all techniques are interlinked with the machine, which consumes energy, so an eco-friendly energy production mechanism is still required, which should work in combination with these water purification systems. Furthermore, researchers have also focused on water quality and water resource management studies using different techniques like TOPSIS [10], Fuzzy [11], Support Vector Machines (SVMs), Bagging Regression and Random Forest Regression [12], The Analytic Hierarchy Process (AHP), and the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) [13] as Multicriteria Decision-Making (MCDM) tools for solving complex decision-making problems in different regions of the world.

In this study, the focus is to develop a mechanism to produce clean water from wastewater polluted canals, as a surface water source. In this research, a power-producing Belgian vortex turbine has been proposed in combination with a water treatment mechanism. The turbulence machine will produce sufficient energy for the working of a treatment setup to produce clean water for the eco-friendly environment and utilization. This study can elevate the health structure of millions of people who are not receiving enough clean water for themselves. If enough clean water and a hygienic environment are available for everyone, the figure of five million mortalities caused by water quality-related issues can be reduced.

2. Background

The most sudden and striking change for living organisms is the lack of availability of clean water resources. Many countries of Asia and Africa will be facing freshwater scarcity according to the predictions of the year 2025 [14]. These countries do not have any water resources left behind. This will be a cause of water scarcity and a big problem for food production, quality of the environment, and the health of humans. More than 80% of water is used for irrigation in these countries [15]. The only way to supply water to industries and for domestic purposes is to divert irrigation water to them [16]. After water re-allocations, crop production will decrease, and countries will be bound to import food [17]. It is said that the blue revolution is required to end the scarcity of water and to save water for agriculture [18]. It requires efficient irrigation methods, for example, a sprinkler and drip irrigation to decrease water wastage [19]. An increase in the recycling of water is also required. While the lack of clean water is getting much attention from persons who make policies about water resources and from other people, providing domestic water in villages is also not considered an issue. Policies about water management have given more importance to water used for drinking than for domestic purposes, as it is just a small percentage of clean water used in these countries. Such as water used for domestic purposes in Pakistan in 1990 was a 26-m^3 for domestic use as compared to a 1226-m^3 for irrigation [14]. Many people think that a little diversion from the irrigation department will be enough to fulfill the need for water for domestic use. However, practically, this will be extremely hard, and even a good idea may fail because of the limited thinking of people and priorities of professionals. The main problem is the decrease in the quality of water. The reason for this is the waste from industries, agriculture, and cities and less investment in the construction of domestic water supply systems. The worldwide issue for an extremely high quality of water is set by Western people [20]. Such people drink extremely clean water, and groundwater is not acceptable to them for drinking. On the other hand, the people who have to manage water for agriculture find their tasks very difficult, because they have to fulfill the plant's need with a limited amount of water [21]. Few managers also must supply irrigation water for domestic purposes. The planners for water supply do not notice the usage of water for domestic purposes in villages, because it is a little percentage of the total clean water being used in a country [22]. This can cause a big problem, as investments have only been made about the water used for agriculture. The provision of domestic water is then often left to local communities and private organizations. This will force poor people to pay more, and they will eventually be drinking less water, as they will not be able to buy it in the required amount. Instruments to develop canal water and seepage aquifers better for domestic purposes is possible only if people of all fields work together. If domestic water will get more importance in managing irrigation water, only then can health be improved in communities living in irrigated areas. Different types of turbines are also installed on water channels to generate electricity. As the generation of power from these resources is always easy to utilize, it is also economical. Therefore, the installation of turbines on the watercourse makes an easier way to generate low-cost eco-friendly electricity [23–25]. Vortex Belgian turbines [24] have been installed in different locations like KPK province (Pakistan), Central Kenya, Dominican Republic, Zambia, Japan, the Democratic Republic of the Congo, Hubei Province, China, Georgia, and Austria [26]. The specification of sample vortex turbines has been explained in Table 1.

Table 1. Vortex Turbine Specifications [24].

Vortex Turbine Models 5 to 70 kW	Unit	Value
Min. Flow	m^3/s	0.7
Max. Flow	m^3/s	4
Min. Head	M	1
Max Head	M	4.4
Min. Speed	rpm	80
Blade tilt angle range	deg	(−14) to 14
Stainless steel type	–	304

As per the explanation of the profile of turbines produced to generate electricity at a small level to entertain small villages where water resources are available, the relationship of power production with water head level can be seen in Figure 1, and Table 2 explains the series of power generation turbine levels to install as per requirements.

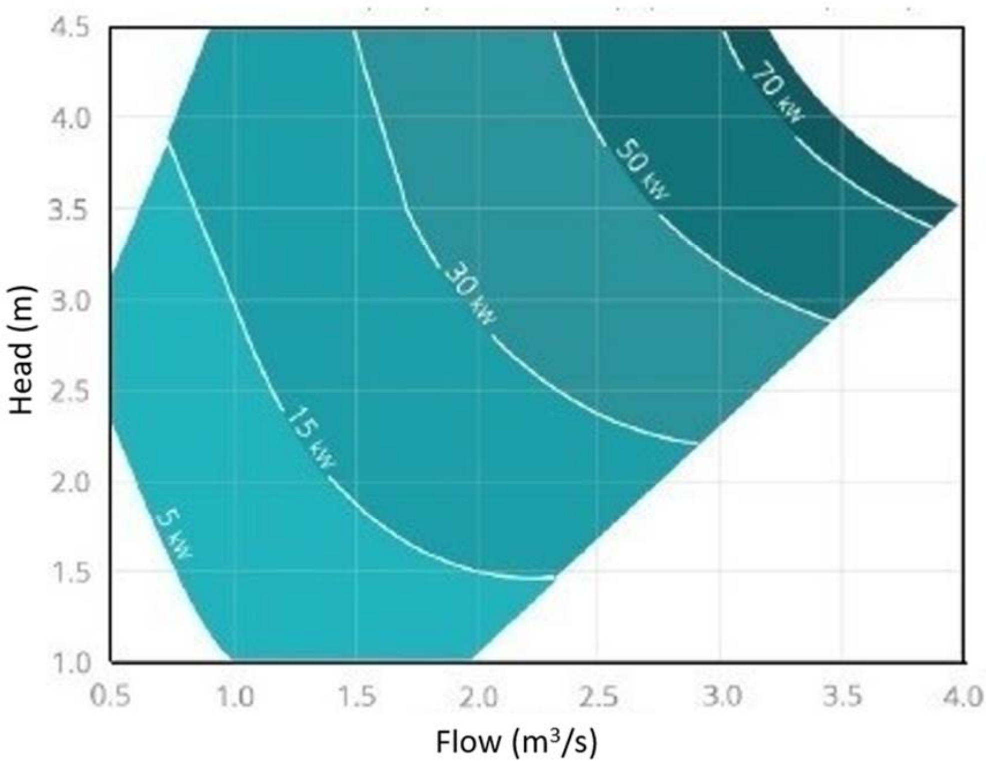

Figure 1. Flow (m^3/s) vs. Head (m) [24] relationship for Electric Power Generation (kW).

Table 2. Belgian Vortex Turbine Models [24].

Representative Models	Unit	5 kW	15 kW	30 kW	50 kW	70 kW
Turbine hydraulic output	kW	5.8	17.4	34.9	56.8	79.5
Electrical output	kW	5	15	30	50	70
Maximal energy generation per year	kWh	40,000	120,000	240,000	400,000	560,000
Nominal flow	m^3/s	0.7	1.5	2.2	3.1	3.8
Nominal head	m	1.6	2	2.8	3.25	3.7
Impeller diameter	mm	800	1140	1200	1300	1500
Rotor height	mm	385	550	580	625	730
Vortex turbine core weight	kg	135	275	300	360	475
Generator and gearbox weight	kg	180	350	600	950	1200
Electrical cabinet. weight	kg	220	270	330	390	480

These vortex turbines are easy to install and can be utilized as per the lower water head profile location without affecting fisheries' life and ecology.

3. Materials and Methods

3.1. Study Area

The area of study was Multan, a section of Nobahar canal up to Faiz distributary covering a wide range as shown in Figure 2. This distributary was commissioned with an authorized discharge of 8.72 m^3. The culturable command area (CCA) of this distributary is 189.4 km^2 out of the gross command area (GCA) of 191.4 km^2. The distributary has been polluted after the inculcation of untreated sewage of 2.26–2.83 m^3 from urban areas of the Multan district. The inclusion of sewage in the distributary has affected the quality of irrigation water, owing to the increased level of salinity and concentration of toxic elements.

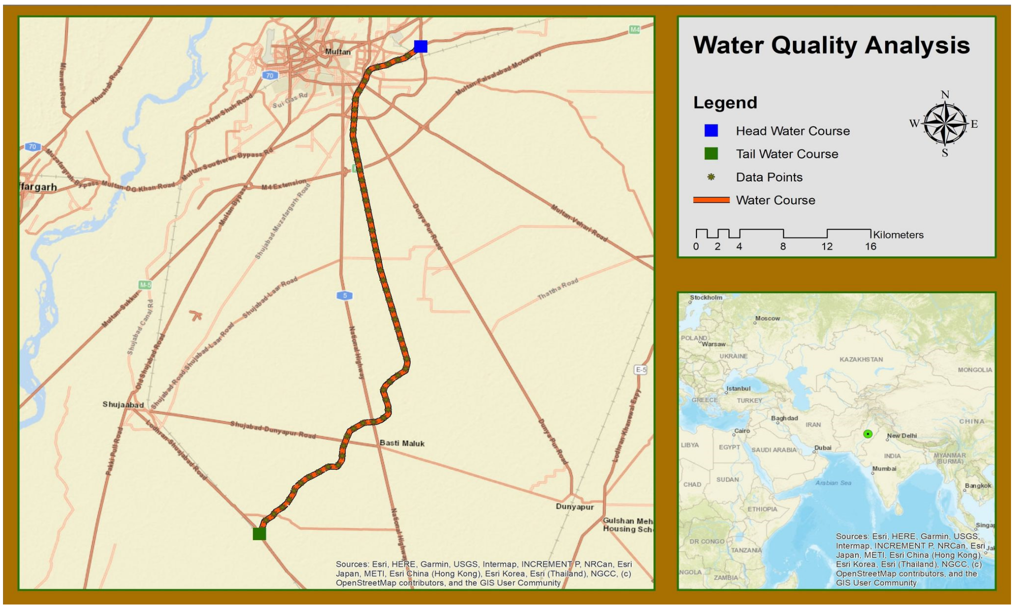

Figure 2. Site Location of Nobahar to Faiz Water Course.

The only source of an application of water to the crops of this region is from this distributary, as the tube well source is expensive and underground water is brackish. The distributary is lined to increase the duty and efficiency of the system. This study was carried out to arrive at the determination of the quality of water following the level of salinity. The water of this distributary, divided into different equal segments, was sampled after each mile. The study was focused to know the suitability of water based on the treatment process and different water quality approaches. The segmental view of the watercourse shows its track to end at the tail.

3.2. Study Framework

This study has been designed in two phases, as shown in Figure 3. The first phase contains two sections; in the first section, a Belgian vortex turbine has to be installed segment-wise on the course of the water channel for power production, and in the second section, that generated power will be utilized to operate the water treatment/distillation plants for the operation of water treatment/distillation to attain water suitability for human and agriculture use. The first phase includes two-step working to select the study area as a water channel and dividing it into different segments (km-wise). After segmentation, a Belgian vortex turbine must be installed on each km. That turbine will help in the production of power; because of the Whirlpool design of the turbine, it works according to the flow of the channel, and pressure is not a major contributing factor. It does not change the ecological pattern of water channel flow, even fishes are safe within that whirlpool design of the turbine. The production efficiency according to the design pattern and requirement can be selected, as given in Table 2. Later in the second step, generated power will be utilized to operate water treatment plants to obtain useable water. Therefore, the same watercourse that is polluted with wastewater will be purified to be transformed into clean water by using generated power from the same water. Each section of the watercourse will develop power ranging from 15–100 kW, depending upon the requirement of the water treatment plant. A normal treatment plant produces 25–50 liter of clean water per min. That much efficiency is quite sufficient to cover any rural region requirement because such a type of facility was not available before. Furthermore, in the second phase of the study, a before and after physio-chemical analysis of water is necessary to evaluate the performance and working of procedure and treatment plants as well. Surface water mixed with wastewater is not feasible for the consumption of humans, but usually treated/distilled water is found to be fit for use according to WHO/FAO standards. Therefore, an eco-friendly solution will be available for clean water supply to humans and the community.

3.3. Phase-I: Power Generation Mechanism Using Belgian Vortex Turbine

The thought behind the turbulent plant is moderately straightforward and can be applied legitimately inside waterways or ashore. Whenever introduced ashore, an opening about 1.5 m in breadth is burrowed, with two trenches joined to bring the water from a close-by source. A two-level impact is consolidated into the plant to help make a whirlpool. A solid bowl is set up inside the gap, containing a generator and impeller, with the earth at that point set up back. At the point when a stream or waterway divider is raised, water streams into the bowl, making the whirlpool and driving the turbine. The entire establishment for a solitary turbine is intended to last around seven days. The plant and generator are available in five sizes, between 5, 15, 30, 50 and 70 kW but can be designed up to 100 kW. The turbine can likewise be based on a slope, although with a stature inclination of close to 3 m for 100 m. In a stream or trench, the whirlpool turbine is set up legitimately inside the stream in an independent way. Setting up a solitary whirlpool turbine in such a manner can give power 24 h daily utilizing the water stream and can control up to 60 houses on account of its 100-kW model. However, Turbulent is likewise planning to help bigger networks that may have issues getting to power or that are looking for cleaner choices. As indicated by the organization, numerous turbines can be set up along a similar trench or stream, basically consolidating their capacity to give more vitality without the requirement for a problematic bit of foundation like a dam. As indicated by the exchange distribution, such hydro-power plants can give as much as 10 megawatts (MW) in power yield, which can create enough vitality to control a little city of 300 individuals. Regardless of the size of the establishment, the set-up cycle and upkeep are intended to be without bother. Tempestuous pledges that little upkeep or fixes are required since the whole turbine has only one moving part, does not influence fish movement, and can be distantly checked. Since its dispatch in 2018, the whirlpool turbine has been introduced in six distinct nations, for both private and mechanical purposes. Tempestuous has set up these turbines in France, Indonesia, and Chile; however, its biggest venture to date, including six of its greatest 100-kW turbines, is at present being worked on in different countries. The water from the resource is siphoned by an engine from a characteristic store, as shown in Figure 4. The siphon supplies the water into the capacity tank, which is then conveyed when regarded as important. The turbine changes over the dynamic vitality of streaming water into mechanical vitality. The turbine engine is pair to the alternator by the shaft. The mechanical vitality is then changed into electrical vitality by the alternator. If the water is raised at the potential level, which is needed to move the turbine sharp edges during the stream, so electrical vitality will be created. The turbine is planned in such a manner to have minimal impact on the characteristic water stream. The turbine water is then provided to homegrown water tanks, and the power delivered is either utilized straightforwardly or can be put away for later use in batteries and so on.

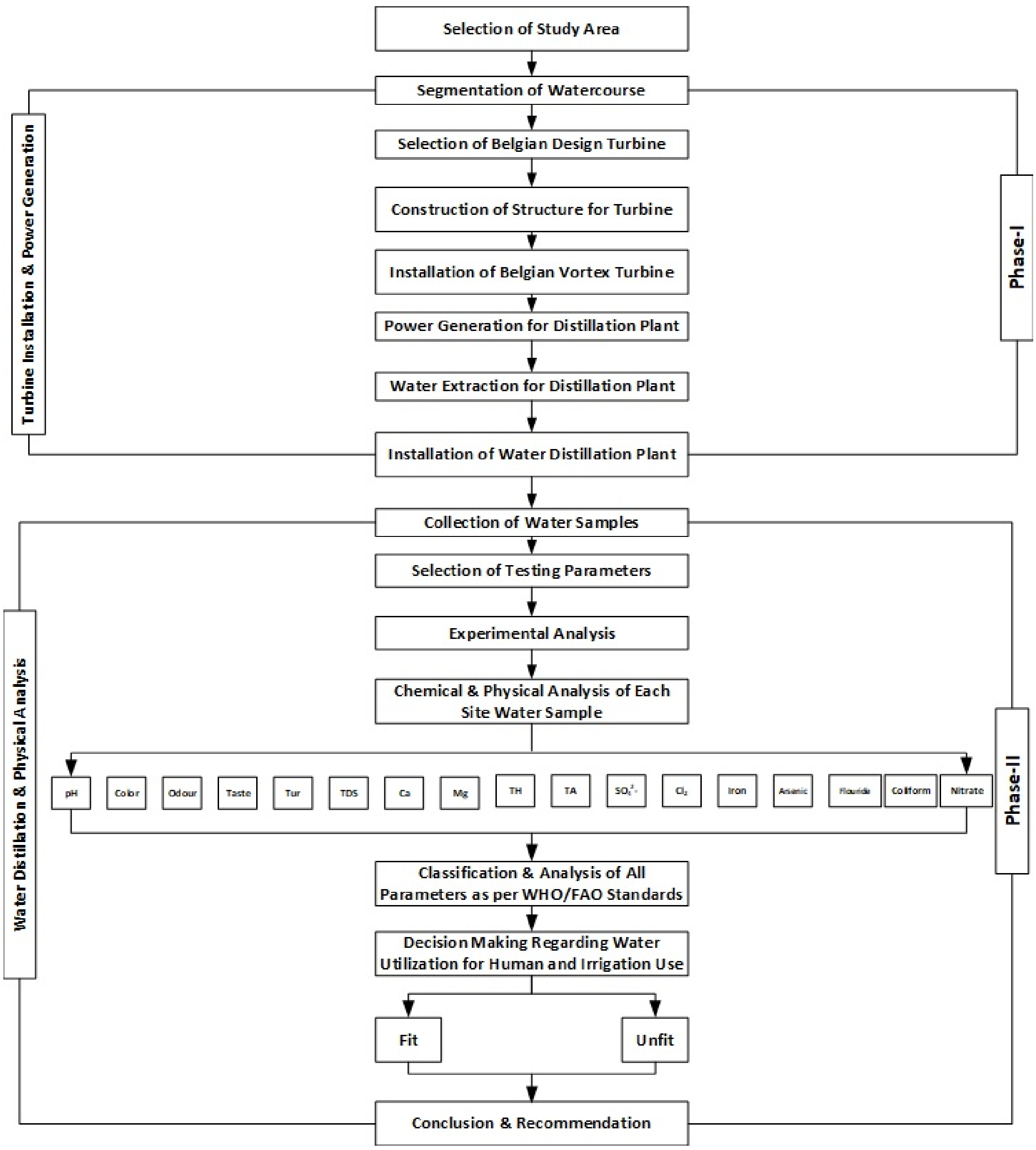

Figure 3. Conceptual Research Framework for Study.

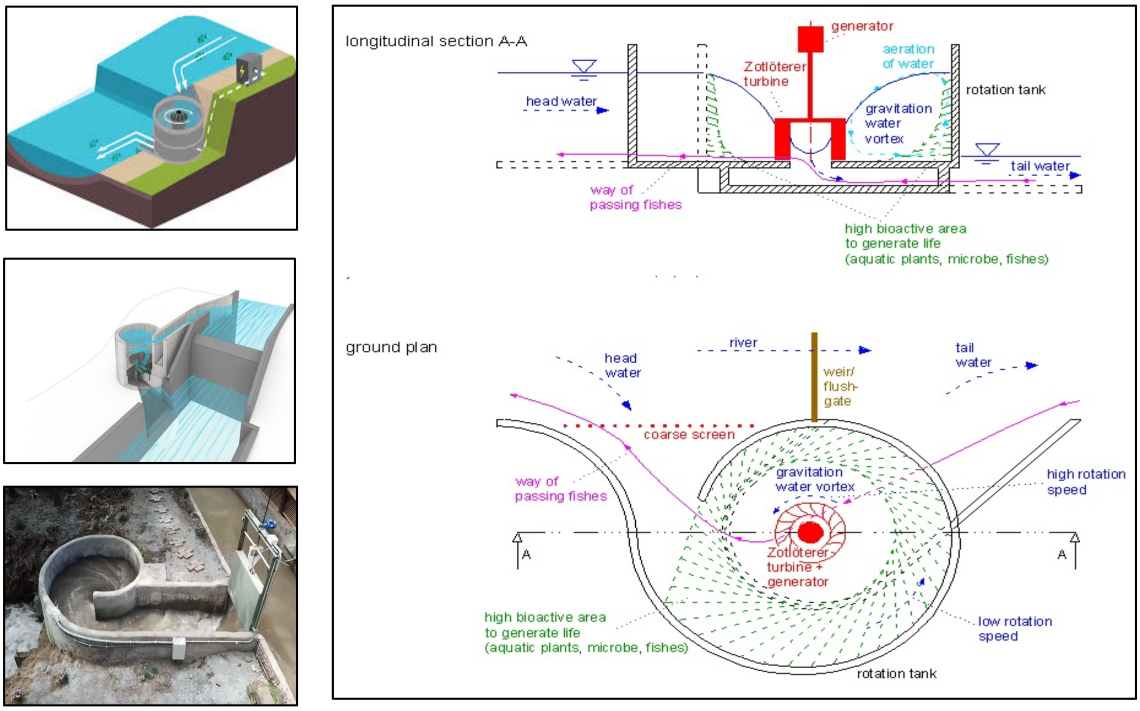

Figure 4. Belgian Vortex Turbine [24], Vortex formation concept [27], Installation, and Mechanism.

The mechanical performance of the turbine is already established because these series of turbines have been successfully installed on different channels for different parts of the world. Further, the requirement for water treatment plants is usually 10–15 kW, so it is easy to utilize these types of turbines for power production and to fulfill the requirement. The concept behind turbine installation was that these whirlpool types of turbines are eco-friendly and can even provide electrical power to 60 homes if required according to water flow conditions following the graphical data provided in Figure 1. Therefore, turbines are installed as per the profile series and requirements

The energy accumulated in water due to its elevation from any reference point is known as potential energy and has a conventional calculation mechanism as explained below [28]. The water in the storage is kept at a high head for the stockpile. Therefore, the potential energy is given as:

$$E_h = mgH \tag{1}$$

where

E_h = hydroelectric energy
m = mass of water in the storage
H = height of water level from respecting turbine
g = gravity acceleration with value of 9.81 m/s^2

$$\mathrm{m} = \rho\ \mathrm{V} \tag{2}$$

$$E_h = \rho\ \mathrm{V} g\ H \tag{3}$$

The density of water is 1000 kg/m^3

By dividing both sides of the equation with time,

$$\frac{E_h}{t} = \frac{\rho\ \mathrm{V} g\ H}{t} \tag{4}$$

$$P_h = \rho \, Q \, g \, H \tag{5}$$

$$P_e = \eta P_h \tag{6}$$

$$P_e = \eta \, \rho \, Q \, g \, H \tag{7}$$

Turbine efficiency varies from 50% to 70%. We say it to be about 60% for the running time.

$$P_e = 0.60 \times 1000 \times 9.81 \times 20 \times Q \; P_e = 117.72 \times Q \;\; \text{kW} Q\,(ac.) = C_d \times a \times \sqrt{(2gh)} \tag{8}$$

Here,
a, represents area of the orifice
C_d, represents the discharge coefficient which is equal to the product of contraction coefficient and velocity coefficient.
h, represents the height of the water level
Let us assume the value of $C_d = 0.62$

$$a = \pi \, r^2 \tag{9}$$

where r is equal to 0.4 inches and the effective radius of the discharge pipe

The level of water source changes over time and is thus kept as it is.

$$Q\,(ac.) = 0.62 \times 0.0508 \times \sqrt{(2 \times 9.81 \times h)} \tag{10}$$

$$Q\,(ac.) = 0.02226 \times \sqrt{(h)} \; \text{m}^3/\text{s} \tag{11}$$

From the above equation, it is now evident that we have a differing discharge for different heads. Now for every value of h, there is a different value of Q, and thus a different value of P_h.

3.4. Phase-II: Water Quality Assessment and Treatment Process

According to the UN, the 1980s was the decade of sanitation and water supply. The first problem in this concern was to make engineers agree to use low-cost technology that was suitable for poor people. As a result, such technology was quite widely accepted, but then it was realized that only this is not enough. It was also necessary that all should have the training, health, and hygiene education, including women. Even if it was successful, the implementation process was disappointing. As a result, another meeting took place in this regard, but instead of water supply solutions, it focused on how to get a responsible approach from people. This revealed the reality that where people demand more water, the chance of a plant to succeed is greater. For the water system to continue, people should contribute to building the system, and after building it, they should run the system themselves. It consists of the fee of users and the system's administration. For this, water must become an economic good that will fulfill human needs, secure food, finish poverty, and protect life. However, water is not seen economically on Earth. Water used in irrigation is mostly free, and in cities, the cost of water used for drinking hardly meets the price of delivery. Subsidies and distorted incentives result in water wastage. Water should be considered good that can also be used for trade. Some people will argue against this and say that this would be nice for the rich, but not for the poor. A minimum amount of safe water is essential for life, and everyone should be entitled to it. It is argued that the involvement of the public in domestic water management will be necessary. Water quality improvement is the prime target to be dealt with during the efficient utilization of wastewater mixed canal water, as it is dangerous to human health. Even for agricultural purposes, it is not suitable due to the mixing of hazardous materials. Installation of water treatment/distillation plants in combination with each vortex turbine can help in the production of clean water as shown in Figure 5. The purified water can be tested as per the environmental water quality standards of WHO and FAO. According to WHO standards of drinking water quality and FAO standards for irrigation water quality, water quality is monitored, and time to time testing will help to monitor the suitability of water for human use. Usually, installed water filtration/purification plants are already approved as per standards. Even Reverse Osmosis (RO) plants have membranes to filter water according to the required standard as per the physiochemical analysis of water following the chemical testing of water profile. Therefore, it is ensured to maintain the water quality standards according to the WHO/EPA for human utility and agriculture as well. Comparative analysis of progress and quality improvement of water purified after installation of treatment plants provides a healthy environment for consumption of this type of clean water resource in an eco-friendly way.

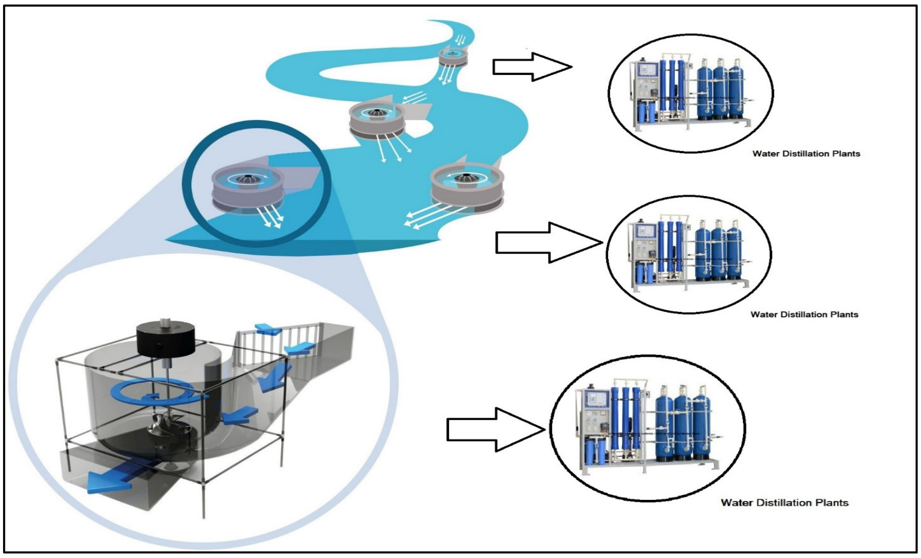

Figure 5. Installation of Water Treatment/Distillation Plants in combination with Vortex Turbine [24] at each station.

The samples of wastewater mixed irrigation water were analyzed for various physio-chemical parameters. Samples were analyzed and calculated to determine the overall quality of the irrigation water following the pattern of previous studies [29]. Table 3 shows the parameters and the method/instruments required for the analysis of water quality.

The pH values ranging from 6.5–8.4 are considered to be within an acceptable range when compared with FAO–UN guidelines as shown in Table 4 [30]. Decision-making regarding the suitability of water is done following the guidelines provided as the basic requirements. These guidelines are a set of the pattern of parameters as per WHO/FAO, known as standards. The physiochemical analysis usually provides an overview of the water profile. The addition of wastewater to canal water contaminates water with toxic ingredients, and it is necessary to clean such water resources before use. In the rural area, canal water is available, but due to the inclusion of these types of wastewater channels, water is polluted, and its suitability is affected. For the consumption of safe water, it is necessary to test this type of water for salinity, toxicity, and infiltration issues, so that a filtration/treatment procedure must be adopted to transform water into a consumable product. Installation of a two-stage concept of a Whirlpool turbine with water treatment/distillation plants can do this for polluted water. Water production ranging from 100,000 to 150,000 ltr. /day with a working hour–8–10 h per day capacity is suitable for a certain range of population living in rural areas. The working capacity increases and decreases with the physicochemical properties of water, as different membranes are installed to maintain a 200 to 15,000 TDS range.

Table 3. List of Selected Parameters [29].

S. No.	Parameters	Analysis/Instrument/Calculation
1	Temperature.	Thermometer
2	pH	Eco pH tester
3	Electrical conductivity (EC)	Conductivity meter
4	Total dissolved solids. (TDS)	Electrical conductivity × 640
5	Chloride. (Cl)	Titration
6	Sodium. (Na)	Flame Photometer
7	Calcium & Magnesium. (Ca & Mg)	Titration
8	Carbonate and Bicarbonate. (CO_3 & HCO_3)	Titration
9	Sodium absorption ratio. (SAR)	$\frac{Na}{\sqrt{(Ca+Mg)/2}}$
10	Sodium Percentage. (SP)	$\frac{(Na+K)}{(Ca+Mg+Na+K)} \times 100$
11	Residual sodium carbonate. (RSC)	$(CO_3 + HCO_3) - (Ca + Mg)$
12	Permeability Index. (PI)	$\frac{(Na+\sqrt{HCO_3})}{(Ca+Mg+Na)} \times 100$
13	Magnesium ratio (MR)	$\frac{Mg}{(Ca+Mg)} \times 100$
14	Potassium. (K)	Flame photometer

The parameters listed are prime indicators for testing water quality, out of which pH value is most important.

Table 4. FAO–UN Guidelines for Irrigation Water Quality Parameters [30].

Potential Irrigation Problem	Parameters		Degree of Restriction on Use		
			None	Slight to Moderate	Severe
Salinity	Electrical Conductivity dS/m		<0.7	0.7–3.0	>3.0
	Total Dissolved Solids		<450	450–2000	>2000
Infiltration based on SAR and EC	SAR	Electrical Conductivity (dS/m)			
	0–3		>0.7	0.7–0.2	<0.2
	3–6		>1.2	1.2–0.3	<0.3
	6–12		>1.9	1.9–0.5	<0.5
Toxicity	Sodium (Na) meq/L		<3	3–9	>9
	Chloride (Cl) meq/L		<4	4–10	>10
Miscellaneous Effects	Bicarbonate (HCO_3) meq/L		<1.5	1.5–8.5	>8.5
	Potassium (K) mg/L			0–2	
	pH			6.5–8.4	

4. Results and Analysis

4.1. Power Generation Mechanism

The difference in power output versus different parameters such as head, discharge, and time is shown in Table 1. Additionally, the discharge falls as the level of water drops, shown in the graph of Figure 2. In Figure 1, the power output is plotted vs. decreasing discharge. The power output is reduced because it is directly related to the discharge available. In Figure 1, the graph shows that the decline in water level, as well as the subsequent decrease in discharge, has influenced the power to be produced. The power output decreases continually concerning the time that is not needed. The inflow is then equal to the outflow, and the head is kept in the water resource at a constant level. The following outcomes are achieved. In Table 5, the power output and time are presented in the case of constant head explaining an equation (using eq. 8)-based analysis. When the variation in the inflow and outflow is equal to zero, then the constant head in the water resource is attained. The power output stays at a constant level, which improves the efficiency of the system thus reliability is achieved. Table 5 present below depicts the average discharge rate with average power generated throughout the day with fixed head size.

Table 5. Power generation profile of turbines efficiency and water head level.

Power Generation Through 50% Efficient Whirlpool Turbine				Power Generation Through 60% Efficient Whirlpool Turbine				Power Generation Through 70% Efficient Whirlpool Turbine			
Time (t) min	Head (h) m	Discharge (Q) m^3/s	Power (P) kW	Time (t) min	Head (h) m	Discharge (Q) m^3/s	Power (P) kW	Time (t) min	Head (h) m	Discharge (Q) m^3/s	Power (P) kW
1	5	10.00	981.00	1	5	10.00	1177.20	1	5	10.00	1373.40
2	4.9	9.80	961.38	2	4.9	9.80	1153.66	2	4.9	9.80	1345.93
3	4.8	9.60	941.76	3	4.8	9.60	1130.11	3	4.8	9.60	1318.46
4	4.7	9.40	922.14	4	4.7	9.40	1106.57	4	4.7	9.40	1291.00
5	4.6	9.20	902.52	5	4.6	9.20	1083.02	5	4.6	9.20	1263.53
6	4.5	9.00	882.90	6	4.5	9.00	1059.48	6	4.5	9.00	1236.06
7	4.4	8.80	863.28	7	4.4	8.80	1035.94	7	4.4	8.80	1208.59
8	4.3	8.60	843.66	8	4.3	8.60	1012.39	8	4.3	8.60	1181.12
9	4.2	8.40	824.04	9	4.2	8.40	988.85	9	4.2	8.40	1153.66
10	4.1	8.20	804.42	10	4.1	8.20	965.30	10	4.1	8.20	1126.19
11	4	8.00	784.80	11	4	8.00	941.76	11	4	8.00	1098.72
12	3.9	7.80	765.18	12	3.9	7.80	918.22	12	3.9	7.80	1071.25
13	3.8	7.60	745.56	13	3.8	7.60	894.67	13	3.8	7.60	1043.78
14	3.7	7.40	725.94	14	3.7	7.40	871.13	14	3.7	7.40	1016.32
15	3.6	7.20	706.32	15	3.6	7.20	847.58	15	3.6	7.20	988.85
16	3.5	7.00	686.70	16	3.5	7.00	824.04	16	3.5	7.00	961.38
17	3.4	6.80	667.08	17	3.4	6.80	800.50	17	3.4	6.80	933.91
18	3.3	6.60	647.46	18	3.3	6.60	776.95	18	3.3	6.60	906.44
19	3.2	6.40	627.84	19	3.2	6.40	753.41	19	3.2	6.40	878.98
20	3.1	6.20	608.22	20	3.1	6.20	729.86	20	3.1	6.20	851.51
21	3	6.00	588.60	21	3	6.00	706.32	21	3	6.00	824.04
22	2.9	5.80	568.98	22	2.9	5.80	682.78	22	2.9	5.80	796.57
23	2.8	5.60	549.36	23	2.8	5.60	659.23	23	2.8	5.60	769.10
24	2.7	5.40	529.74	24	2.7	5.40	635.69	24	2.7	5.40	741.64
25	2.6	5.20	510.12	25	2.6	5.20	612.14	25	2.6	5.20	714.17
26	2.5	5.00	490.50	26	2.5	5.00	588.60	26	2.5	5.00	686.70
27	2.4	4.80	470.88	27	2.4	4.80	565.06	27	2.4	4.80	659.23
28	2.3	4.60	451.26	28	2.3	4.60	541.51	28	2.3	4.60	631.76
29	2.2	4.40	431.64	29	2.2	4.40	517.97	29	2.2	4.40	604.30
30	2.1	4.20	412.02	30	2.1	4.20	494.42	30	2.1	4.20	576.83

Figure 6 present below shows the performance curve of the turbine with 50%, 60%, and 70% efficiency. The graph clearly shows the increase in power generation as the discharge rate increases, due to the change of head size. With higher efficient systems, more output power can be generated to drive the water filtration process plant.

4.2. Water Quality Mechanism

In dry and half-dry areas of the earth with less domestic water, but a large amount of irrigation water, only irrigation water is typically used for drinking. When this unclean canal water is used by humans for drinking purposes, diseases may spread. Additionally, if proper sanitation facilities are not present, interstitial germs/parasites can contaminate irrigation canals. This will lead to contamination of crops, and, when used for washing, cooking, and drinking, can spread disease. To increase farm efficiency, large doses of fertilizers and pesticides are often used and, if these agrochemicals get leaked into the river/stream, etc., they will pollute water and can harm life inside it. Pesticides are used in canals to control weeds and snails to prevent schistosomiasis. If people living in villages use irrigation water, the huge quantity of water will give more health risks than benefits due to the low quality of water. Even with a large amount of water with health benefits, there will also be indirect effects of irrigation. At places where separate water for drinking is available, people mostly use irrigation water to take baths and wash clothes, for animals to drink, and for households. Wastewater can be brought back to canals instead of soiling mud houses that have no sewerage. People living in irrigated areas often supply irrigation water to home gardens. Such gardens can have fruit on them, and the trees give shade and provide wood. Livestock rearing also depends on irrigation water. More milk is produced in Pakistan and India if irrigation water is available as compared to when salty groundwater is the only option. Irrigation water also helps in developing economic activities, which may be small scale or large scale. These village industries will contribute to regional income.

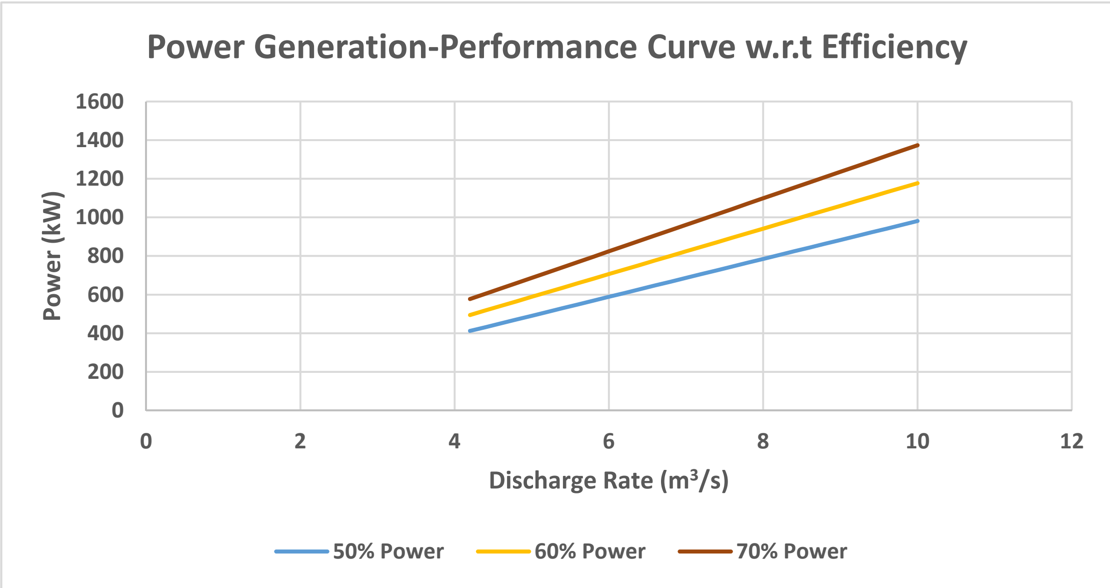

Figure 6. Performance curve of turbine with 50%, 60%, and 70% efficiency.

Here, presented data in Table 6 shows the quality of water taken from three sources. The values of S-1 (canal water) do not qualify for the "Fit" range. If this water is used as it is for drinking purposes, it can damage the human body. From the analysis of water quality samples, we can conclude that it is necessary to treat/distillate the water sample using an improved quality of water source. It will help in the conservation of groundwater sources and will also help in the efficient utilization of surface water sources.

Table 6. Water Quality Testing for Available Resources.

Parameters	WHO Standards	PCRWR Standards	S-1	S-2	S-3
Temp	25	25	32.8	32.3	34.9
pH	6.8–8.5	6.5–9.2	7.7	8.1	7.85
Color	Un-obj	Un-obj	Yellowish	Yellowish	Colorless
Odor	Un-obj	Un-obj	Un-obj	Un-obj	Un-obj
Taste	Un-obj	Un-obj	Un-obj	Un-obj	Un-obj
Tur.	5 NTU	2.5–5 NTU	59	41.6	0.45
TDS	1000 mg/L	500–1500 mg/L	193	44	243
Ca.	200 mg/L	200 mg/L	24	6	40
Mg.	150 mg/L	30–150 mg/L	5	1.25	15
TH	500 mg/L	500 mg/L	70	20	160
TA	Not Set	Not Set	2.3	5	0.9
SO_4^{2-}	400 mg/L	200–400 mg/L	30	15	30
K	12 mg/L	12 mg/L	7.2	3.8	3.8
Na	200 mg/L	200 mg/L	31	12	43
Cl_2	250 mg/L	200–600 mg/L	15	15	90
HCO_3	1.0 mg/L	1.5–8.5 mg/L	115	25	45
EC	–	–	298	69	405
Remarks	–	–	Unfit	Moderate	Fit

Note: S-1 (Canal Water Sample), S-2 (Filtered Water Sample), S-3 (Distilled Water Sample).

5. Discussion

A population of greater than one billion people is not receiving enough clean water for itself. If enough clean water and a hygienic environment are available for everyone, five million mortalities caused by diarrhea can decrease [31]. This study has been designed for the solution of the problem identified in previous researches [29]. With the growing problems, there is no improvement in domestic water resources because of the increasing lack of water and decrement in water quality. Cities, industries, and the environment are demanding more water in developing countries. In these countries, no water sources are left behind, and new ones cannot be developed. Therefore, water can only be diverted from agriculture, which utilizes about 90% of the water in the developing world. In addition to these, people in the whole world are trying to get more crops with less water. Unluckily, efficient irrigation does not mean that other sectors will be receiving more water. When water allocations are being discussed, the focus should be on actual savings of water, not just those savings that decrease the amount of water being beneficially used. Locally, efficient irrigation will decrease the amount of domestic water. For example, the concrete lining of irrigation canals in different countries [32] has decreased leakage of water so much that water went below the reach of people. This water was used for drinking. If irrigation water is decreased, managers may lose some of the system or the whole system. This will be a problem for groundwater levels and also for domestic water availability if the separate supply for domestic water is not available. In South Asia, groundwater resources are being used at a very fast rate for providing enough water for irrigation. The fast growth of tube-wells in Bangladesh reduced the amount of groundwater so much that it had a tremendous effect on the amount of drinking water [33]. Lastly, a change in the way of cropping will result in less water for people living there. Even if water saved from efficient agriculture is used for other purposes, it will not be enough. Therefore, demanding more and more water resources for domestic use, industries and agriculture will be wrong. Instead, wastewater from cities should be for irrigation, and irrigation water should be used for domestic purposes. This is possible only if policies regarding water resources include every use and user of water.

Except for giving water to crops, water from irrigation canals is utilized for livestock, rearing aquatic animals and wildlife, etc. Irrigation water is frequently used for taking baths and for laundry [34]. In dry and semidry areas without a proper supply for domestic water but with enough irrigation water, only irrigation water can be used for drinking. People will drink this water if its color, look, smell, and taste are fine. Now, irrigation water is being planned to be used for domestic use. The most common step in this was washing clothes with irrigation water. Mostly, designers for irrigation systems just focus on water used by crops [35]. On the other hand, domestic water suppliers hardly consider irrigation water an option. People who make policies on water supply say that people do not use water from unprotected sources. Instead of it, they should use clean water with no pathogens in it. Therefore, the nonagricultural use of irrigation is decreased. This paper shows proof of connection/linkage between water quality and water supply.

Many diseases in developing countries are caused by poor water supply for domestic use, no sanitation, and an unhygienic environment. Studies about the impact of water on health were studies related to parasitic worms in water [36]. The figures about persons affected by different diseases are incorrect [37], but even then, diarrhea is the most common water-related disease in both aspects: (1) persons affected and (2) persons dead. Children under five face diarrhea about 2.6 times a year and 3.3 million children of this age group die every year [38]. For a long very period, drinking polluted water was known as the biggest cause of diarrhea. However, many previous studies on the impact of the supply of water on diarrhea showed serious issues [39]. Nowadays, water quantity has been given more importance to decrease diarrheal patients, and people are becoming aware of interrelationships between the supply of water, sanitation, health, and hygiene [40]. Now, water quantity is considered more important than its quality [41]. It is because, with enough water, diarrhea can be decreased. For this, we should separate watery diarrhea and diarrhea with blood. Polluted water is just one cause of cholera and watery diarrhea. Shigella is also a cause of diarrhea and is mostly transmitted through unwashed fingers after feces. In developing countries, most mortalities through diarrhea take place in malnourished children. The type of diarrhea is mostly dysenteric [42]. Secondly, passing out feces in a clean way and improvement in hygiene are more important than water quality, and they also have many health benefits [41,43]. Good quality of water decreases diarrhea only in families living in a clean and safe environment with sanitation facilities [44]. It means improved water supply has no benefits if sanitation does not improve. There will be benefits if improvements are made in both the supply of water, water quality, and sanitation [41,43]. Sufficient water very near to the house motivates people to utilize water; this improves their health. This is also necessary to avoid diseases linked to the amount of water. Trachoma is an example, and it can be prevented by washing the face [45]. Improvements in the supply of water will also give benefits other than decreasing diseases, such as saving energy and time. When less time takes place for collecting water, adult females can spend time preparing food and taking care of their children, while young girls can spend time on studies at school.

Water pollution through agricultural chemicals and industrial waste containing poisonous metals is a global issue. In developed countries, the issue of availability of water was solved; water pollution through chemicals is now the main problem. In poor countries, infectious diseases linked with water will be more important problems than the effects of industrial pollution and agrochemicals on water. In developing countries with a big industrial sector, chemical pollution is not the biggest problem, but the real problem is microbiological pollution [46]. Wastewater recovery is considered a reasonable choice to enhance water supplies in water-short territories. Specifically, layer treatment has assumed a significant function in filtering water cost-adequately. Water treatment and purification mechanisms have appeared to fundamentally reduce total dissolved solids, heavy metals, organic pollutants, viruses, bacteria, and other dissolved contaminants [47]. Commercial level experiments have explained that wastewater treatment plants that are well designed and installed according to standard guidelines have performed efficiently. The procedure of designing a layer-based water treatment plant is directly linked with the physicochemical properties of water samples taken at regular intervals because membranes are added as per the detected pollution level of the wastewater [48]. Therefore, sometimes procedures are included in the blended plants for water and drainage cleanup, containing reverse osmosis and ultrafiltration membrane mechanism for water treatment [49]. That is why different types of water treatment plants have been tested by different researchers to evaluate comparative performance [50]. Even then, we should control the number of chemicals used in fields to prevent excessive water pollution, which will be good for people's health. An example of a field in which chemicals have extensively used the field and because of this water contamination reaches beyond the limit [51]: pollutants are at the maximum level at end of the irrigation systems. If pollutants cannot be separated from the system, the best policy is not to use such chemicals that pollute water, and this policy should be strictly followed. Therefore, a two-phase combine system of vortex turbines with a water distillation setup can provide a better water quality for human utilization.

6. Conclusions

This study focuses on water quality improvement using the Belgian vortex turbine machine in combination with the water distillation system. Growing water shortage and change in understanding the relationship between water quality and diseases makes the study of irrigation water is used for domestic purposes and its health effects, a relevant and timely topic. As diarrhea is a big factor of morbidity, as well as deaths in the developing world, it is taking place mostly due to water shortage instead of transmitting through the water. That is why water quantity is more important than water quality. To supply water in the developing countries of the world, it is necessary to use an irrigation system. The barriers in designing systems for using irrigation water for domestic use will be psychological and institutional instead of logical, epidemiological, and economic. Self-claimed efficient irrigation systems will be responsible for the water shortage for non-agricultural purposes supplied from the irrigation system. Along with that, cost-effective technology must be used to provide clean water in irrigated areas. As water and health are closely related, improving water supply will improve health. Studies that intend to make improvements in irrigation water should be appreciated. Qualitative research and surveys will provide knowledge about the domestic water supply system in droughts. Additionally, the information on the non-agricultural use of irrigation water will give a good approximation of irrigation water's value. This will also lead to more studies on the relation between non-agricultural use of irrigation water and disease. This study will help to improve the demand and supply situation of clean water related to the health structure of more than one billion people who do not have access to clean water, especially in developing countries. Five million water-quality-related mortalities can be decreased to a large extent if enough clean water is available for everyone.

7. Limitations of the Study

This study has been conducted based on a conceptual joint combination of Belgian vortex turbine and treatment/distillation mechanism. Belgian vortex turbine is relatively simple and different from conventional turbines and can be applied directly on the rivers and water channels. It is designed on a different mechanism, which helps to create a whirlpool and works for different output levels, between 5, 15, 30, 50, 70, and 100 kW. A set up of a single whirlpool turbine with specific head height can produce power up to 100 kW, 24 h a day using the water flow. This conceptual study will need detailed experimentation for finding the most suitable combination of solutions for an economical and eco-friendly water resource recycling and recovery in the future.

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