Potentiality of Power Production from Gebeit Alsharaf Dam, Red Sea State, Sudan

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Abstract— **The purpose of this research is to study the possibility of using water power to drive a hydraulic turbine installed in the drinking water pipeline emerging from a dam. The dam is constructed in the Red Sea state by the Dams Implementation Unit Kaleidoscope to solve water supply problem by harvesting and storing rainwater. In this study the required data is collected from the site of the dam and analyzed in terms of hydrological and topographic studies. Using this data, the flow rate of water through the pipe is estimated by applying the energy equation using Excel program analysis. Given flow rate and available head, the power is calculated and found to be about 19.39 kW. Suitable turbine and generator is selected. Finally, the results are compared with those obtained when using the program (Hydro Help - CLOVA issue, January 2010) and found to give very close agreements.**

Keywords— **Power production; hydraulic turbines; Gebeit Alsharaf Dam; Red Sea State; Sudan.**

Nomenclature

DIU	**Dam Implementation Unit**
MHS	**Micro Hydropower System**
MHP	**Micro Hydropower Project**
DC	**Direct Currant**
SHP	**Small Hydro Power**
AC	**Alternately Currant**
HDPE	**High Density Polythene**
m	**Meter**
m3	**Meter Cube**
Km	**Kilo Meter**
Sq.	**Square**
f	**Friction factor**
L	**Length of the Pipe**
D	**Pipe diameter**
v	**Average Velocity**
g	**Gravitational Acceleration**
P	**Power**
H	**Head**
Q	**Water Flow Rate**
ρ	**Density**
η	**Overall Efficiency**
MW	**Mega Watt**
h	**Hour**
N_R	**Reynolds Number**

I. Introduction

The aim of this research is to study the possibility of using water power to drive a hydraulic turbine installed in the drinking water pipeline emerging from a small dam located in red sea area. Refer to references [1] – [33].

Sudan is the one of the largest country in Africa, the country extends gradually from the desert in the north, with its hot dry climate and almost no vegetation cover, to the African Sahel zone in the center (dry to semi-dry climate) with its light and dense savannah, to the sub-tropical region in the south with heavier rains and dense tree cover. In terms of rainfall, Sudan is one of the driest but also the most variable country. Extreme years (either good or bad) are more common than average years. The majority of agricultural activities depends on rainfall, which is erratic and varies significantly from the north to the south of the country. In many parts of the country people suffering from water shortages and scarcity. Therefore, they are forced to drink with their animals from ponds because it is less expensive. The unreliable nature of the rainfall, together with its concentration into short growing seasons, heightens the vulnerability of Sudan's rain fed agricultural systems as well as drinking water in many areas like Red Sea State. Over the last century, the Red Sea State has experienced, at least, fourteen cycles of drought, which affected its livelihood system. Highly complex concerts of factors, both natural and induced have combined to create a situation of structural poverty. The economic potential of the Red Sea Region appears to be quite favourable but hinges on the sustainable availability of usable water.

Government of Sudan has planned to implement an integrated program for water harvesting, particularly for relief in shortage of water supply to people and livestock in Red Sea state. Therefore, a number of convergent projects are planned to build across the state for storing and harvesting rainfall runoff. Gebeit Alsharaf Dam is among those projects. It has been planned to be constructed near Sinkat area in the Red sea state, for sustainable drinking water storage. Gebeit Alsharaf Dam Project is located Upstream of Sinkat Town, on Gebeit Khor locally known as Khor Yuyetb, to address the water supply needs of the people and livestock of the area. Gebeit Khor is a non-perennial stream that collects run off from its drainage basin during the rainy season which extends from August to November. The rain fall in the area is very low, the runoff flows away due to the lack of necessary storage areas. Therefore, water availability for the local people and their livestock is insufficient and the existing facilities for water supply and distribution show serious deficiencies. In general, the demand for water exceeds its availability and the overall situation of the city is characterized by regular shortages, which result in bad environmental conditions. The problem is increasing from day to day due to increasing demands. Dam Implementation Unit of the Federal Ministry of Water Resources and Electricity is undertaking water harvesting projects to supplement water supply to the people and livestock. DIU commissioned Shoura Consult Company and AGES Consultants Pakistan for design and implementation of the water harvesting projects. The goal of development is socio-economic enhancement of the local communities through:

- Establishment of water storage reservoir along the Gebeit Khor.
- Enhance water availability and reliability for drinking and farming.

Drinking outlet works are required to release the water impounded in a reservoir for drinking purpose. At Gebeit dam Project the main purpose of the outlet works is to deliver water supplies downstream of the dam to provide drinking water to the downstream area. The same outlet works should also be used for diversion of river supplies (municipal supplies) during the construction of the dam. This can also be used for regulation of minor flood flows. Engineering Consultancy Center and Water Corporation in Red Sea State designed the drinking water pipe from Gebeit Alsharaf dam to Sinkat and Gebeit towns as shown in Figures (1) and (2). [Red Sea Engineering Consultancy Center].

Fig. 1 Water Pipeline from Gebeit Dam to Gebeit Town

Fig. 2 Water Pipeline from Gebeit Dam to Sinkat Town

The water pipeline from Gebeit dam to Sinkat town Figure (2) needs some pumps for pumping more water. Therefore, the pipeline must be connected to the pipeline coming from Aposhedh dam so that it can feed Sinkat town [Red Sea Engineering Consultancy Center]. But water pipeline from Gebeit dam to Gebeit town which is shown in Figure (1) is almost straight and there is enough gradient head that takes water flow to Gebeit town by gravity.

II. OBJECTIVES

The main objective of this study is to study the possibility of the potential of hydro power for the establishing of a hydraulic turbine in the line of water pipes, in Gebeit Alsharaf Dam in order to convert the available energy of water into electrical energy.

III. LIMITATIONS OF THE STUDY

The study is limited in several fronts. Firstly, the focus of the study is on Micro Hydropower System(MHS) rather than small, medium or large hydropower plant (HPP). Each of which requires totally different approach to system design. Secondly, although the investment and design of MHS is oriented primarily for generation of electricity for consumption, the study focuses only on the technical specification and design of MHS rather than designing network for electricity distribution which in turn requires a totally different perspective in system design. Thirdly, the actual implementation process of MHS is inevitably affected by the local political, legal, social and economic environment, which are not the focus of this study; rather it is concerned mainly with the technical design and implementation of the dam. Also, the choice of components and geography are limited by financial considerations, although they might not be implemented with a strict financial rationale. Therefore, consideration of financial factors in choice of components and geography are omitted from this study.

IV. Hydro Power Project Classification

Hydro power projects are generally categorized in two segments i.e. small and large hydro as explained in reference [34]. Different countries are following different norms keeping the upper limit of small hydro ranging from 5 to 50 MW. However, there is no consensus on the definition of small hydropower. Some countries like Portugal, Spain, Ireland, Greece and Belgium, accept 10 MW as the upper limit for installed capacity. In Italy the limit is fixed at 3 MW (plants with larger installed power should sell their electricity at lower prices) and in Sweden 1.5 MW. In France the limit has been recently established at 12 MW, not as an explicit limit of medium hydropower (MHP), but as the maximum value of installed power for which the grid has the obligation to buy electricity from renewable energy sources [35]. In the UK 20MW is generally accepted as the 5 thresholds for small hydro. Though different countries have different criteria to classify hydro power plants, a general classification of hydro power plants is shown in Table (1) below.

Table -1 Hydro Power Project Classification

Type	Capacity
Large- hydro	More than 100 MW and usually feeding into a large electricity grid
Medium-hydro	15 – 100 MW - usually feeding a grid
Small-hydro	1 - 15 MW - usually feeding into a grid
Mini-hydro	Above 100 kW, but below 1 MW; either stand alone schemes or more often feeding into the grid
Micro-hydro	From 5kW up to 100 kW; usually provided power for a small community or rural industry in remote areas away from the grid
Pico-hydro	From a few hundred watts up to 5kW

V. Methodology

A micro turbine is a wonderful way to generate you own electricity because it is so ecologically friendly [36]. It has little or no impact on the environment and will provide continuous energy year-round at low cost. Unfortunately, not many of us can access this resource since it usually requires a large track of land with a stream. For those of us who live in the countryside, it is possible that you could have a stream nearby on public land that you could access. In this case it may require a longer line (or penstock) to get the water from its source to your land where you will put your micro turbine. This paper is about how you can figure out how much energy will be available considering your terrain and water availability. Generally, there are two types of micro hydro system, flow of stream and storage type. However, in this paper, the system is based on storage type. A micro hydro system converts the potential energy of water into electricity by the use of flowing water. This water flows in water streams with different slopes giving rise to different potential for creating heads. The capacity of power is dependent on the head and flow rate as shown in Figure (3).

VI. Head

The head, H (in meters) and Z is the vertical height difference between where the water would enter the intake pipeline or penstock and turbine. Hydro sites can be categorized according to the available head for hydro system, the greatest fall over the shortest distance is preferable when choosing a hydro site. However, more head is usually preferable since power is the product of head and flow. So, less flow is required at a higher head to generate similar amounts of power. With a higher head, the turbine is able to run at a higher speed. If a high head is available, a smaller turbine and generator might be necessary for the same flow and the water conveyance system can also be smaller and thus less costly.

VII. Water Flow Rate

The water volume is simply measured as the flow rate, Q (in cubic meters per second) of the water which is usually limited by the size of the stream. The larger the stream the more water is available for a hydro development. However, not all the water can be diverted from a river for use in power production, as water must remain in the river for environmental reasons. Nevertheless, other solutions are possible where no water is diverted such as storage type micro hydro system.

VIII. Power Generation

In micro hydro system, there are two factors which determine the power potential of the water flowing in a stream i.e. flow and head. The potential power can be determined as:

$$P = g \times \rho \times Q \times H \qquad (1)$$

This potential energy will turn into kinetic energy when the water falls down over the head through the pipeline. This kinetic energy is kind of pressure which will rotate the shaft of hydraulic turbine. Mechanical energy from turbine then will drive synchronous generator to produce electricity in term of alternating current (AC). The electricity will then be distributed to residential, commercial and industrial complexes. The AC power supply must be maintained at a constant 50 or 60 cycles/second for the reliable operation of any electrical equipment using the supply. This frequency is determined by the speed of the turbine which must be very accurately governed.

IX. Results And Discussions

Based on the field survey data, the study dealt with designing the major civil components for the Gebeit Dam project [37]. Based on the design parameters, the calculations carried out helped to determine the Powerhouse components of the Micro Hydro Project. The various components are summarized in Table (2).

Table -2 Hydro Power Project Classification

Crest of Dam	**878.5m**
Normal water level	**877 m**
invert elevation of Bottom outlet	**868 m**
Diameter of outlet pipe	**0.30 m**
Effective head from center of outlet	**9 m**
Total length of pipe	**9200 m**

A. Head Measurement

Normal water level= Crest of Dam - 1.5

= 878.5 - 1.5= 877 m

Effective head from center of outlet = 877 - 868 = 9 m

Static head = Effective head+ pipe elevation

= 9+67 = 76 m

B. Selection of Penstock

The optimal pipe size and material of the penstock was calculated from the Engineering Consultancy center and Water Corporation in Red Sea State. The results lead to selection of High Density Polythene pipe (HDPE).

C. Estimated Water Flow Rate

From equation (2) the maximum flow in the penstock is calculated, by applying the energy equation and substituting the turbine head equal zero (i.e. without turbine) we get: **Refer to references [15] – [17].**

$$76 = \frac{fl}{d}\frac{v^2}{2g} + \frac{v^2}{2g} + (H_t = 0) \qquad (2)$$

$$76 = \frac{fl}{d}\frac{v^2}{2g} + \frac{v^2}{2g} \qquad (3)$$

Equation (3) is solved by iteration methods and using excel program, we get.

$$v = 1.9446\frac{m}{s} \qquad Q = 0.1374534\frac{m^3}{s}$$

D. Calculated Potential Power

The flow rate is reduced to determine the turbine head existing by using excel program. The maximum head is found at the minimum flow rate which is shown in Figure (3) below.

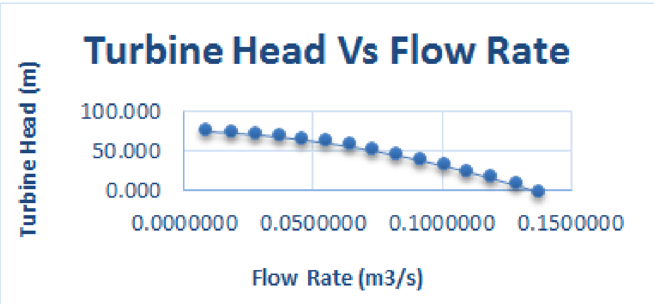

Fig. 3 the Turbine Head Vs Flow Rate

Moreover, that the flow rate is reduced to know the power existing in the turbine by using excel program. It is found that, the power existing is increased when the flow rate is decreased up to the maximum and then is decreased shown in Figure (4) below.

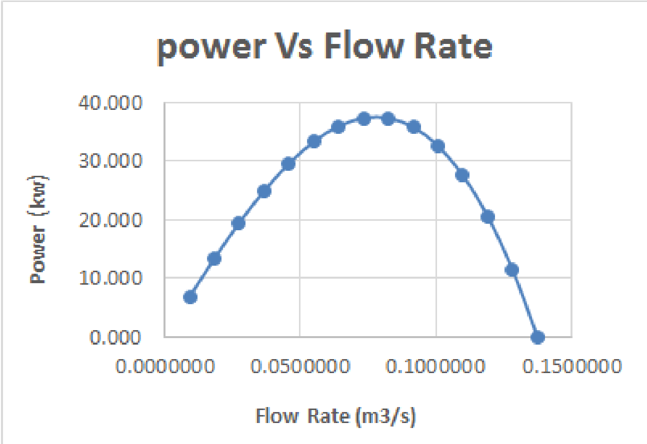

Fig. 4 the power Vs Flow Rate

For the different static head, the turbine head and power existing is calculated as shown in Table (3).

Table -3 Hydro Power Project Classification

Static head (m)	**Maximum flow rate (m3/s)**	**Design flow rate (m3/s)**	**turbine head (m)**	**Power (kw)**
76	**0.1374534**	**0.0824720**	**46.074**	**37.276**
75	**0.1364619**	**0.0815466**	**45.682**	**36.544**
74	**0.1354643**	**0.0808795**	**45.117**	**35.797**
73	**0.1344604**	**0.0798756**	**44.765**	**35.077**
72	**0.1334503**	**0.0788655**	**44.411**	**34.360**
71	**0.1324336**	**0.0778488**	**44.055**	**33.644**
70	**0.1314104**	**0.0768256**	**43.695**	**32.931**
69	**0.1303804**	**0.0757956**	**43.333**	**32.220**
68	**0.1293436**	**0.0747588**	**42.967**	**31.511**

E. Turbine Selection and Efficiency

In a MHS system, the hydraulic turbine is the primary component which converts the energy of the flowing water into mechanical energy through the rotation of runners. The choice of particular turbine depends upon technical parameters such as design head and discharge at which the turbine is to operate, as well as other practical considerations such as the availability and cost of maintenance personnel. The optimum speed of the turbine is the particular speed of its rotor at which the turbine performs its best performance. The turbine needs to operate at this optimum speed in order to get maximum possible output at all loading conditions**.** The suitable turbine is selected by considering the turbines' type field of application chart [38] which is shown in Figure (5) and also could be found by using (Hydro Help - Turbine selection - CLOVA issue, January 2010), the suitable turbine is Turgo turbine which is shown in Figure (6). It is found that the result is similar when using the two methods.

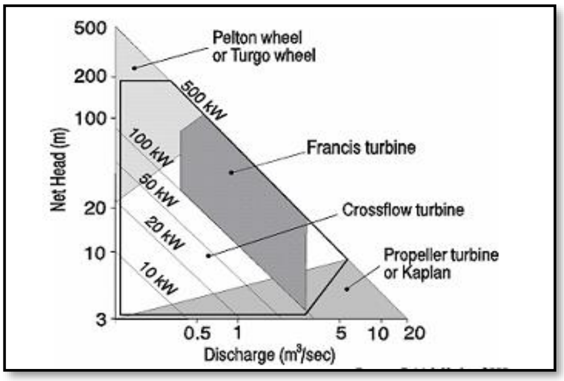

Fig. 5 Turbines' Type Field of Application

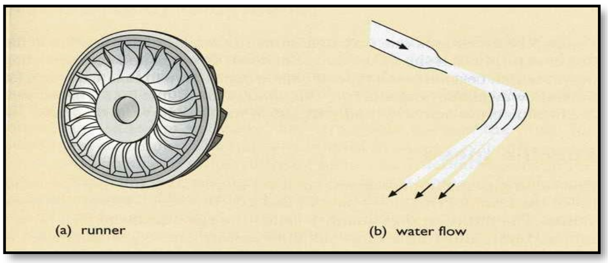

Fig. 6 Turgo Turbine: (a) runner; (b) water flow

Typical efficiency variation range of turbines and water wheels are given in Table (4) below. For more precise figures, turbine manufacturers should be consulted. Turbines are chosen or are sometimes tailor-made according to site conditions. Selecting the right turbine is one of the most important parts of designing a micro-hydropower system, and the skills of an engineer are needed in order to choose the most effective turbine for a site, taking into consideration cost, variations in head, variations in flow, the amount of sediment in the water and overall efficiency [39]. Typical efficiency ranges of Turgo turbine by referring to Table (4) was found to be (80-95) %.

Table -4 Variation Efficiency Ranges of Turbines

Prime Mover	Efficiency Range
Impulse turbines:	
Pelton	80–90%
Turgo	80–95%
Cross-flow	65–85%
Reaction turbines:	
Francis	80–90%
Pump-as-turbine	60–90%
Propeller	80–95%
Kaplan	80–90%
Water wheels:	
Undershot	25–45%
Breastshot	35–65%
Overshot	60–75%

For the minimum value of the efficiency we get:
The power existing from turbine = 37.3*0.8= 29.84 kw

F. The Generator Selection and Efficiency

Induction generator is the suitable type of generators in MHP (Micro Hydro Project) because they can operate at variable speeds with constant frequency, they are available and cheap and requires less maintenance than the synchronous generators. The efficiency of induction generators is approximately 65 percent at part load [40].
The power existing from generator =29.84*0.65=19.39kw
Also, method (Hydro Help - Turbine selection - CLOVA issue, January 2010) was used to calculate the power existing from generator, and it gave the same result.

G. Selection of the Turbine Location

The turbine could be constructed in different locations on the penstock by neglecting the exit pressure from the turbine, the maximum power existing in maximum static head is shown in Table (5). In conclusion if a maximum power is needed, than the turbine must be located near Gebeit town, otherwise the power is reduced.

Table -5 Turbine power in the Different Locations

Flowrate (m3/s)	static head (m)	pipe dia (mm)	pipe length (m)	Turbine Head (Ht)	power (kw)
0.0733085	9	300	60	8.788	6.320
0.0733085	24	300	1060	21.168	15.223
0.0733085	33	300	3580	23.566	16.948
0.0733085	49	300	5060	35.689	25.666
0.0733085	76	300	9200	51.843	37.283

The average energy produced per year and the average flow rate per year of the turbine are shown in Table (6), it is observed that in 21 hours the flow rate becomes greater than the storage capacity of the dam, which means the operation time between (1-20) hours per day is suitable.

Table -6 Energy and Flow Rate produced in Hour per Year

Time (h/day)	Energy (Mwh)/ year	flow rate (m3/year)	Time (h/day)	Energy (Mwh)/ year	flow rate (m3/year)
1	12.55	103495	13	163.15	1345431
2	25.10	206989	14	175.70	1448926
3	37.65	310484	15	188.25	1552421
4	50.20	413979	16	200.80	1655915
5	62.75	517474	17	213.35	1759410
6	75.30	620968	18	225.90	1862905
7	87.85	724463	19	238.45	1966399
8	100.40	827958	20	251.00	2069894
9	112.95	931452	21	263.55	2173389
10	125.50	1034947	22	276.10	2276883
11	138.05	1138442	23	288.65	2380378
12	150.60	1241936	24	301.20	2483873

Therefore, the suitable operation time must be ranged between (1-20) hours per day. These results must be corrected if the losses of Interception, Evaporation, Transpiration Evapotranspiration, Infiltration and Watershed leakage are neglected.

X. CONCLUSIONS

Hydropower is a clean source of energy. The water being stored contains potential energy due to its height i.e. head. This potential energy is converted into kinetic energy due to gravity and then supplied to the required places. The potential energy goes unutilized. It can be used to obtain useful work for generation of energy, this makes effective utilization of potential energy that would otherwise waste. This paper presents an overview of using the potential of hydro power from the Gebeit Alsharaf Dam in eastern Sudan to generate micro hydro electrical power. Some of the main points and conclusions are summarized below:

1- Review the study and detailed engineering design of the dam.
2- Measuring head and Water Flow Rate.
3- Use of flow water in overhead dam to generate electricity power.
4- The power is calculated and found to be about 19.39 Kw
5- The better turbine selected for this case is Turgo turbine and Typical efficiency ranges of Turgo turbine is (80-95) %.
6- The settable type of generators in MHP Induction generators and the approximate efficiency is 65 percent at part load.
7- To get the maximum power the turbine must be located near Gebeit Alsharaf town.
8- The maximum operation time should be less than 20 hours per day (if we ignore the losses of Interception, Evaporation, Transpiration Evapotranspiration, Infiltration and Watershed leakage).
9- The results are compared by using (Hydro Help – Turbine selection - CLOVA issue, January 2010) and the results are found to be very close

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REFERENCE

[1] Garman P., 'Water Current turbines', a field worker's guide, II publications, London, 1986.
[2] Blue energy Canada, http://www.blueenergy.com, accessed 6 March 1999, 30 Sept. 2002.
[3] Hilton D. J., 'A vertical axis water turbine for extracting energy from rivers and tidal currents', proceedings of the 1st international conference on technology for development, I E Aust/ ADAB et al, Canberra, 24-28 November 1980, pp. (138-141).
[4] Baker A. C., 'Tidal power, Peter peregrinus Ltd, 1991.
[5] Pearce F., 'Catching the tide', new scientist, 20 June, 1998, pp. (34-41).
[6] Fraenkel P.L., Cultterbuck P., Stjernstrow B. and Bard J. 'Sea How', preparing for the world's first pilot project for the exploitation of marine currents at a commercial scale, proceedings of the 3rd European wave energy conference, Patras, Sept-Oct. 1998.
[7] Fraenkel P. L., 'Tidal currents', a major new source of power for the millennium, sustainable development international No. 1, 1999, PP. (107-112), ICG publishing, http://www.sustdev.org.
[8] Fraenkel P. L., 'Marine Currents', a promising large clean energy source, proceedings of the international mechanical engineering conference, 'power generation by renewables', London, 15-16 May, 2000.
[9] Fraenkel P.L., 'power from marine currents', proceedings of the Inst. Mech. Eng., J. power and energy 216(A1), 2002, PP. (1-14).
[10] Cairo D., Department of Aeronautical Engineering, University of Naples, Pers. Comm, 2001, 2003.
[11] Zoeb Husain, Zulkifly Abdullah, Zainal Alimuddin, 'Basic fluid mechanics and hydraulic machines, BS publications, Hyderabad, 2008.
[12] Rama S.R. Gorla, Aijaz A. khan, 'Turbo machinery design and theory', Marcel Dekker, Switzerland, 2003.
[13] Bernard Massey, 'Mechanics of fluids', Taylor and Francis, USA, sixth edition, 2006.
[14] Bernard Massey, 'Mechanics of fluids-solution manual, Taylor and Francis, USA, eighth edition, 2006.
[15] John F. Douglas, Janusz M. Gasiork, John A. Swaffield, Lynne B. Jack 'Fluid mechanics', sixth edition, Pearson publishers.

[16] John F. Douglas, 'solving problems in fluid mechanics, vol. 2', prentice Hall, 1996.
[17] John F. Douglas, 'solving problems in fluid mechanics, vol. 1', prentice Hall, 1996.
[18] Kari Sornes, 'small scale water current turbines for river applications', January 2010, zero emission resource organization.
[19] Thropton energy, physic lane, Thropton, North umber land NE65 7HV, United Kingdom, January 2010, http://www.throptonenergy.co.uk.
[20] Alternative energy, January 2010, http://www.alternativeenergy-news.info/
[21] S. Gahin, Moustafa M. Elsayed, Mohammed A. Ghazi, 'Introduction to engineering mechanics', King Abdulaziz University, Jeddah, Saudi Arabia, 1985.
[22] Bachelor, G. K., 'An introduction to fluid dynamics, Cambridge University press, 1967.
[23] Duncan, W. J. A. S. Thom, and A. D. Young, 'Mechanics of fluids', the Gresham press, Edward Arnold limited, 1978.
[24] Fox, R. W., and A. T. McDonald, 'Introduction to fluid mechanics', John Wiley and Sons, 1978.
[25] Hughes, W. F. and J. A. Brighton, 'Fluid dynamics schaum's outline series', McGraw – Hill book company, 1967.
[26] James E. A. John, William L. Haberman, 'Introduction to fluid mechanics', Prentice Hall, Inc. 1980.
[27] Massey, B. S., 'Mechanics of fluids dynamics', Van Nostrand company Ltd, 1968.
[28] Kay, J. M. and R. M. Nedderman, 'An introduction to fluid mechanics and heat transfer', Cambridge University press, 1977.
[29] Schlichting, H., 'Boundary – Layer theory', McGraw – Hill, 1968.
[30] Webber, N. B., 'Fluid mechanics for civil engineers', University of Southampton, 1968.
[31] Streeter, V. L., and E. B. Wylie, 'Fluid mechanics, McGraw – Hill Book Company, 1975.
[32] Stephen J. Kline, 'Similitude and approximation theory', McGraw – Hill Book Company, 1965.
[33] Osama Mohammed Elmardi, 'Further Experimental Research Work on Water Current Turbines', Lambert Academic Publishing, (2015).
[34] Ila Dashora, 'Hydraulic Investigations and Analysis for Hydropower Projects', Alternate Hydro Energy Center, Indian Institute of Technology Roorkee, India, December (2015).
[35] Dilip Singh, September 2009, Micro Hydro Power Resource Assessment Handbook, Asian and Pacific Centre for Transfer of Technology Of the United Nations – Economic (APCTT) and Social Commission for Asia and the Pacific (ESCAP).
[36] Noor Azliza BT Ibrahim, July 2012, Modelling of Micro Hydroelectric System Design, degree of Master of Electrical Engineering, University Tun Hussein Onn Malaysia.
[37] Shoura Consult Company Ltd, February 2014, Gebit Alsharaf Dam Rehabilitation 'Final Design Report – Volume 1F', Dams Implementation Unit (DIU).
[38] Jane Wickham, January 2010, Reclaiming Lost Power – Kilkenny's Potential Hydro Power Sites, Carlow Kilkenny Energy Agency.
[39] Josée Bonhomme, Robert Clark, Scott Davis and Stephen Graham, 2004, Hydraulic Energy Program, Renewable Energy Technology Program, CANMET Energy Technology Centre (CETC) in cooperation with the Renewable and Electrical Energy Division (REED), Electricity Resources Branch, Natural Resources Canada (NRCan).
[40] Anil Kunwor, 2012, Technical Specifications of Micro Hydropower System Design and its Implementation Feasibility Analysis and Design of Lamaya Khola Micro Hydro Power Plant, Bachelor's Degree Thesis Industrial Management.