

# Environmental Impacts of Hydropower: The Role of Dissolved Oxygen Level in Water Ecosystem

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Dissolved Oxygen (DO),  
ROR (Run off River)

## Abstract

This paper reports the effects on Environment due to the use of Hydropower. Hydropower is considered to be one of the most used, eco-friendly and sustainable source of energy in Nepal. Besides its various advantages it shows some adverse effects on Environment. One of the high efficient and potential hydropower project named "Padam Khola Hydropower" from Dailekh district is taken as the research area. . Padam Khola Hydropower is selected as the focal region for our research study since the hydropower project requires decent amount of in-flow and also provides decent output (4.8 MW). As the hydropower provides quite satisfactory output, it requires water input in generous amount too, due to which it might carry the potential to disturb aquatic ecosystem. Aquatic ecosystem relies on different ecological and synthetic factors too. Dissolved Oxygen (DO) level is considered one of the key factor for healthy existence of aquatic biodiversity. This research aims to evaluate the DO level of research area. For the study and evaluation of DO level Iodometric titration method is used. Iodometric Titration Method is wide in use due to its accuracy, budget friendly property. The primary objective of this research paper is to evaluate the effect of DO level due to the hydropower. According to Environmental Protection Agency (EPA) DO level less than  $5\text{mgL}^{-1}$  ppm is considered to be in stressful situation for aquatic ecosystem. Moreover, survival of aquatic ecosystem is nearly impossible for the DO level lesser than  $3\text{mgL}^{-1}$  ppm. Lesser amount of DO level indicates scarcity of oxygen in the water, which can have adverse effects aquatic ecosystem. Meanwhile the results of the research conclude the DO level of research area to be  $3.5\text{mg L}^{-1}$  which indicates the average existence of aquatic biodiversity.

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## 1. Introduction

Hydropower is one of the oldest and still in wide use, the knowledge is perhaps the oldest form of energy hydropower has come to light centuries ago. The ability to convert flowing or falling water into

energy while utilizing natural water cycles to produce power with very low environmental pollution makes it appealing. In Nepal, the first hydropower plant was established at Pharping (500-KW) in 1911, 29 years after the world's first plant was established, during Prime Minister Chandra Shamsheer Rana's time to meet the energy requirements of the members of the ruling class.

Hydropower is among the most developed forms of renewable energy, which over the decades has served as a greener alternative to non-renewable sources while also offering a considerable amount of electricity into the energy grid. The most common type of hydropower plant used in Nepal is ROR (Run off River). Water released from the reservoir flows through a turbine, spinning it, which, in turn, activates a generator to produce electricity. But hydropower doesn't necessarily require a large dam. Some hydropower plants just use a small canal to channel the river water through a turbine. Another type of hydropower plant called a pumped storage plant can even store power. The power is sent from a power grid into the electric generators. The generators then spins the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

The creation and utilization of hydropower often include the construction of dams which permanently change the flow of rivers. These developments can lead to the alteration of both aquatic and land based ecological zones. Fish species are especially at risk because dams hinder migration of fish from the river to freshwater quarters for reproduction and spawning. In addition, the construction of new reservoirs would flood a great deal of land and that would take a toll on both animals and plants and would further increase CO<sub>2</sub> emissions as a result of the dying off of decomposed plants.

Among the several challenges that the environment and the people face, the most alarming has been the impact of hydropower plants on the aquatic and the terrestrial eco-systems so far. The environmental impact of hydropower projects is sometimes multi-faceted as these hydropower facilities usually have ripple effects beyond the immediate sites causing adverse impacts in downstream regions. Changes in river flow patterns, water temperatures, and sediment transport could adversely affect local fish populations, as well as their predators. Even the large reservoirs formed through the construction of dams result into the submersion of forests, arable lands and even human populations, causing such people to be dispersed and disorienting their economic activities.

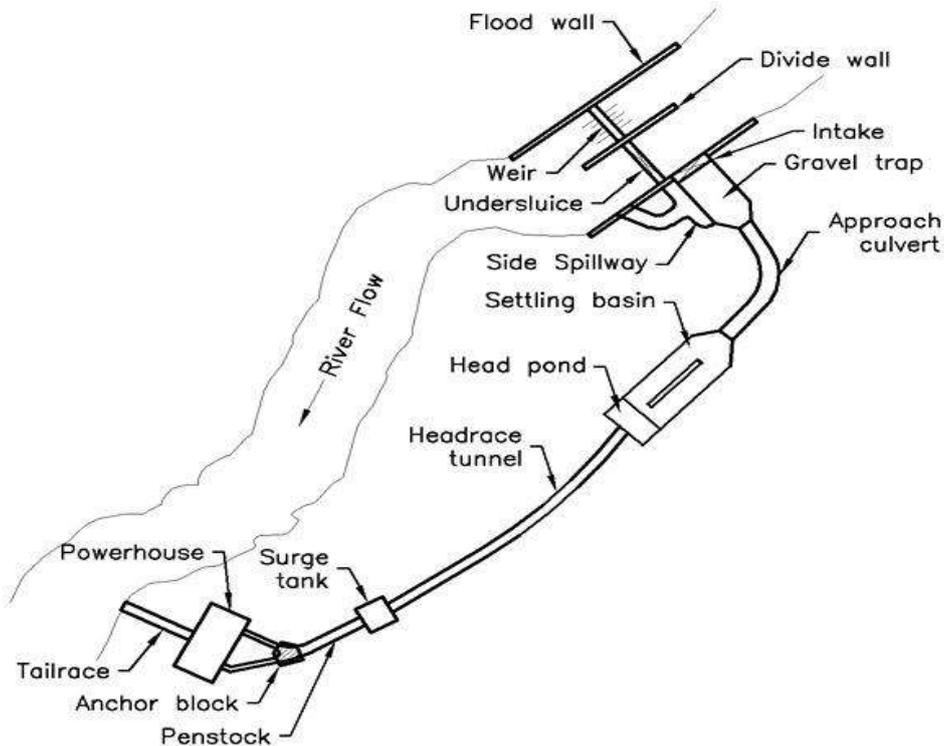


Figure 1: ROR Type Hydropower Plant

### 1.1 Dissolved Oxygen Level

Dissolved oxygen (DO) refers to the oxygen gas ( $O_2$ ) that is dissolved in water, and it plays a crucial role in the health and functioning of aquatic ecosystems. Oxygen in water is essential for the survival of aquatic organisms, including fish, invertebrates, and microorganisms. It is also a key indicator of water quality, reflecting the balance between oxygen production and consumption in aquatic environments. Understanding dissolved oxygen, its sources, and its significance is critical for managing water resources and ensuring the sustainability of aquatic ecosystems.

The quality of the water released from hydropower plants and its impact on the aquatic habitat represents a continuous concern for the main hydro energy providers. The measurement of dissolved oxygen is one of the most recommended and the most important of all chemical methods available for the investigation of the aquatic environment. Dissolved oxygen provides valuable information about the biological and biochemical reactions going on in waters. It is a measure of one of the important environmental factors affecting aquatic life and of the capacity of water to receive organic matter without causing nuisance.

Oxygen gas dissolves freely in fresh waters. Oxygen may be added to the water from the atmosphere or as a by-product of photosynthesis from aquatic plants and is utilized by many respiratory biochemicals, as well as by inorganic chemical reactions. The concentration of dissolved oxygen in water depends also on temperature, pressure, and concentrations of various ions. DO level ( $0-2 \text{ mg/L}^{-1} \text{ppm}$ ) is

considered to have some adverse effects on ecosystem, the range (3-5 mg/L<sup>-1</sup>ppm) is suboptimal and indicates average conditions for aquatic ecosystems. Dissolved Oxygen level range 5-8 mg/L<sup>-1</sup>ppm is considered ideal, signifying favorable condition for aquatic ecosystem.

## 1.2 Contextual Overview of the Research Area

Padamkhola small hydropower station is run of river hydro-electric plant located in Naumule rural municipality-5, Naumule, Dailekh of Nepal. The entire project located along the left bank of padamkhola within Naumule Rural municipality of dailekh. The geographical coordinates of this hydropower project vary from latitudes 28°55'00" to 28°54'02" and longitudes 81°52'30" to 81°49'22". The plant generates 4.8 MW electricity. The design flow is 2.42 m<sup>3</sup>/s and the gross head is 243.4 m. The intake of the project has a catchment area of about 59 km<sup>2</sup>. This plant is developed and owned by IPP Dolti Power Company P. Ltd of Nepal. The plant started generating electricity from 2076-09-08 BS. The power generated from the project is evacuated through 16 km long 33 KV national transmission line to the substation at Dailekh Bazaar. The electricity produced from the project is sold to Nepal Electricity Authority.

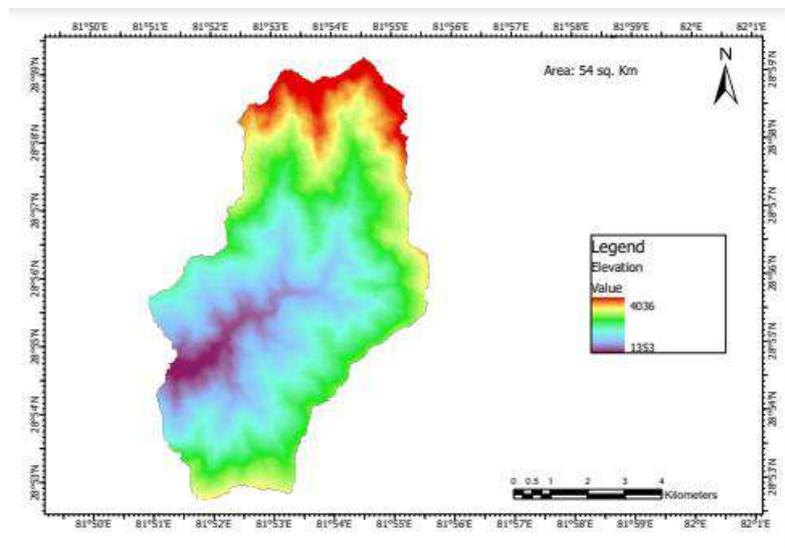


Figure 2: Catchment Area of Padam Khola

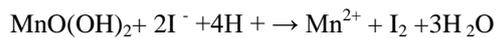
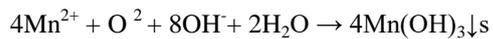
## 2. Experimental

There exist various practices to measure DO level of water. Do level stand for dissolved oxygen level in water. Electrochemical sensors, optical sensor (fluorescence), colorimetric, winkler titration method and many more. Iodometric Titration method is considered more reliable and cost effective method for measurement of Dissolved Oxygen Level. DO titration method does not depend on any external factor like water temperature, pressure, salinity etc., along with the many advantage this method has some limitations. It is time consuming and it requires extreme careful handling of chemicals with accuracy of concentration of required chemical.

Iodometric Titration method is a composition of various chemicals with accuracy of concentration and normality. N/80 Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution is used as tritrant which reacts with iodine to indicate the end of

tritrant. 20% alkaline KI solution is taken as an reference material to standarize sodium thiosulfate (titrant). A strong oxidizing agent is also required in order to oxidize organic matter present in the water level which indicates the indirect demand of oxygen. For Iodometric Titration method potassium dichromate is used as an oxidizing agent. Unstablized presence of sunlight can have some negative impact an the tritration process,inorder to stablize light 0.1N Na<sub>2</sub>CO<sub>3</sub> used.

A 90 ml of sample solution with 2ml prepared KI and 2ml phosphoric acid is mixed and kept still for 10 miutes inorder to form iodine



After the addition of the KI and phosphoric acid ,dissolved oxygen present in the water repeats with mangenese (ii) ions to form mangenese oxide (MnO<sub>2</sub>) which subsequently oxides iodide(I<sup>-</sup>) to iodine (I<sub>2</sub>).The prepered solution is further taken for titration process.As shown in figure tritrants drop are noted inorder to calculate DO level of water

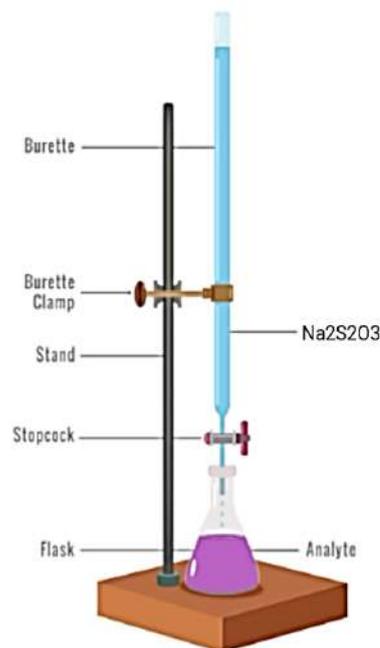
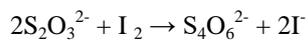


Figure 3: Experimental setup for Iodometric titration method

The following table represents the results obtained from the iodometric titration conducted to measure dissolved oxygen (DO). In order to ensure the accuracy of the DO measurements, this process was performed three times yields the results detailed in the table. After obtaining the required data from titration, the report is further drawn towards calculations.

No. of Obs.	Volume of water sample containing liberated I <sub>2</sub> (mL)	Burette Reading			
		Initial (I)	Final (F)	Difference (D)	Mean Reading
1	100	0	3.5	3.6	
2	100	0	3	3.4	3.5 ml
3	100	0	3.5	3.5	

Table 1: Reading obtained from the Iodometric Titration

Calculation:

$$1000 \text{ ml of } 4 \text{ M thiosulfate} = 32 \text{ g of dissolved O}_2$$

Or,  $1000 \text{ ml of } 1 \text{ M thiosulfate} = 8 \text{ g of dissolved O}_2$

$$(a)\text{ml of } M/80 \text{ thiosulfate} = (8/(1000*a))*(1/80)\text{g of dissolved O}_2$$

$$= (0.1 * a)\text{gm of dissolved O}_2$$

$$\text{Amount of dissolved O}_2 = ((0.1*3.5)/100)*1000 \text{ mgL}^{-1}$$

$$= 3.5 \text{ mgL}^{-1} \text{ of ppm (where } 1 \text{ mgL}^{-1} = 1 \text{ ppm)}$$

### 3. Discussion and Conclusion

As per calculation the Dissolved Oxygen Level of this research is calculated to be  $3.5 \text{ mg/L}^{-1}$  ppm. This research paper focuses on the DO level of water only. According to Environmental Protection Agency (EPA) DO level less than  $5 \text{ mgL}^{-1}$  ppm is considered to be in stressful situation for aquatic ecosystem. Moreover, survival of aquatic ecosystem is nearly impossible for the DO level lesser than  $3 \text{ mgL}^{-1}$  ppm. Lesser amount of DO level indicates scarcity of oxygen in the water, which can have adverse effects aquatic ecosystem. Meanwhile as the results of the research conclude the DO level of research area to be  $3.5 \text{ mgL}^{-1}$ , presence of aquatic animals is predicted to be in small quantity. During the site survey, researchers observations also directs to the lesser availability of aquatic animals in the research area.

### 4. Limitations

Healthy existence of aquatic ecosystem requires many more factors like, temperature, salinity, pressure etc. This research focuses on Dissolved Oxygen level of water only, which is a key factor to determine the health of aquatic biodiversity but it does not deal with the remaining other factors. Other mentioned essential key-factors have not been considered in this research which can cause the changes in chances of aquatic ecosystem survival. The Iodometric method for evaluating Do level of water requires right concentration of chemicals, executive handling of instrument

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