NMHS-Quarterly Progress Report (QPR) – **Pro forma**

Kindly update the NMHS-Quarterly Progress Report (QPR) segregated into the following Part-A. Technical Progress and Part-B. Financial Progress, in respect of the Objectives & Quantifiable Deliverables as per the NMHS-Sanction Letter.

NMHS Grant ID:	NMHS2024-25/SC-XII/SG-98-206/SL-12					Year:	2024
Project Title:	Development of a continuous flow, solar based photoelectrochemical small-scale water purification system for Himalayan springs						
PI & Lead Implementing Organization:	Prof. Prem Felix Siril, Indian Institute of Technology Mandi						
Quarter (please put √):	Qtr. 1	√	Qtr. 2		Qtr. 3	Qtr. 4	
Progress Reporting Period:	from …1/Nov/2024….. to …14/March/2025…						
Project Site(s) covered:	Kataula, Ghoda farm, and Mandi						

Part-A. Technical Progress

(i) Progress against each of the Sanctioned **Objective***

Sanctioned Objectives	Quantifiable Progress against each Objective	*attach* Annexure
• **Objective 01:** To design a layered Perovskite_Conducting Polymer_TiO2 composite photoanode capable for efficient harvesting of solar irradiation for PEC water decontamination. • **Objective 02:** To assemble a carbon-based cathode for synergistic contribution to the water decontamination process through in-situ generation of oxidative H2O2 and its activation. • **Objective 03:** To design and develop a flow photoelectrochemical reactor (PECR), integrated with the photoanode and cathode. • **Objective 04:** To evaluate the decontamination process of flowing water through PECR at the lab scale and then its scalable implementation at the spring sites near IIT Mandi campus. • **Objective 05:** To determine and verify the flow rate after completion of the prototype on all possible water quality parameters	The literature survey has been conducted to find out the suitable materials for the photoanode. Three spring sites were identified and water quality tests were performed thoroughly.	✓ Annexure-I

*As issued in the NMHS-Sanction Letter; also specify the compliance with the General Conditions.

(ii) Progress against each of the Sanctioned **Deliverable** in view of **Monitoring Indicators***

Sanctioned Deliverables	Quantifiable Progress against each Deliverable	*attach* Annexure
• **Deliverable 01:** A functional PECR prototype for online water treatment application in spring water.	5%	
• **Deliverable 02:** Optimized photoanode materials and deposition methods and reliable cathode for H2O2 generation- Patent/Publications.	5%	
• **Deliverable 03:** Optimized operational parameters, well-documented performance under natural sunlight, and demonstrated scalability for large-scale water purification.	0%	
• **Deliverable 04:** Training programs/workshops and building partnerships with the concerned Line agencies & industry for technology translation.	10%	
• **Deliverable 05:** Patent, Knowledge products and research publications (minimum 5 Nos.).	0%	

*As issued in the NMHS-Sanction Letter; also specify the compliance with the General Conditions.

(iii) Progress against **Data**, **Demonstration**, & **Publication**

Particulars	Description with Quantification	*attach* Annexure
• Baseline and Database *collected*:	Water quantity analysis of spring water of Mandi district of Himachal Pradesh	✓ Annexure-II
• Models *demonstrated*:	None	
• Trainings/ Workshops *conducted*:	A detailed survey among the villagers on water quality awareness is being conducted now.	Annexure -III
• Knowledge Products *prepared*:	None	

(iv) **Beneficiaries** & **Stakeholders**

Beneficiaries/ Stakeholders:	Total	Women	Youths	SC	ST	Farmers/HHs	Collaborations
	…	…	…	…	…	…	Jal Shakti Vibhag, H.P.

Part-B. Financial Progress

(i) **Expenditure** under each Budget Head

S#	Standard Budget Heads	Fund Sanctioned	Quarterly Expenditure	% Fund Utilization*	*Remarks, if any*
1.	Professional Services[1]	1,00,000.00	1,31,208.00	>100%	-29604
2.	Training Expenses[2]	20,000.00	0.00	0%	20,000.00
3.	Domestic Travel Expenses[3]	20,000.00	0.00	0%	20,000.00
4.	Office Expenses[4]	20,000.00	18,020.00	90.1%	1980.00
5.	Printing and Publication[5]	0.00	0.00	0.00	0.00

6.	Digital Equipment[6]	10,00,000.00	9,58,066.00	95.8%	41,934.00
7.	Materials and Supplies[7]	28,850.00	28,850.00	100%	0.00
	Total	11,88,850	11,06,540.00		82,310.00

*Per cent (%) fund utilization of the total grant sanctioned under each prescribed budget head by NMHS-PMU.

(ii) Project Staff Information:

S#.	Project Staff *deployed*	Designation	Fellowship/ Emoluments (paid @/ mo)	*Remarks, if any*
1.	Dr. Neha	Senior Project Fellow	28,000	

Note: Kindly take note of the following budget components into consideration to fill the details adequately:

[1] ***Professional Services:*** Hiring charges to various services/ expertise of Govt. and Non-Govt. Institutions, Organizations for conducting Mission activities, and salary of consultants and others NMHS professional staff and payment to other departments for service rendered, Overheads. Number of manpower along with the designation and per month salary should be enlisted and submitted separately.

[2] ***Training Expenses:*** Capacity Building and Training Programs, workshops, extension programs through State Govt. agencies.

[3] ***Domestic Travel Expenses:*** Traveling expenses during the professional services, field visit for various projects sites, and meetings.

[4] ***Office Expenses:*** Recurring and non-recurring contingent expenses, Stationary charges, other Office expenses and Contingency expenses during implementation of various activities, Minor office equipment, Office assistant and Data Entry Operators.

[5] ***Printing and Publication:*** Printing and publication of the books, manuals, papers, etc.

[6] ***Digital Equipment:*** Hardware & software, Minor equipment, etc.

[7] ***Materials and Supplies:*** Lab supplies and materials store, such a light and sound systems, demonstrations models, pilot plant, educations supplies, agricultural supplies, chemical and glassware, spare parts and supplies and goods. A separate list along with per item cost with justification should be mentioned separately.

Annexure-I

Literature Review

This research proposal focuses on developing a continuous-flow photoelectrochemical system for treating contaminated freshwater springs in the Himalayas. The proposed system will harness solar energy, a freely available resource, to purify the water. Himalayan water sources are subject to various contaminants that fluctuate seasonally. Our experimental findings in the vicinity of IIT Mandi indicate the presence of pathogens and harmful compounds that pose serious health risks to people relying on these water sources. To address this problem, the initial goal is to fabricate a high performance photoanode by layering different materials, including perovskite, conducting polymers, and TiO_2, to enhance the system's efficiency. Thereafter, photocathode will be integrated in parallel to form a photoelectrochemical device. These materials are known for their electrochemical properties, photocatalytic activity, and high charge carrier mobility and are expected to form a highly efficient photoanode. By optimizing material composition, and to develop photoelectrochemical, this study aims to develop a sustainable, solar light-driven and cost-effective device for water purification in remote Himalayan regions.

Our primary aim is to deposit the perovskite film on the fluorine-doped tin oxide (FTO) glass substrate. Perovskite is a crystalline material characterized by an octahedral network of BX_6 units at the corners of element "A" [1]. The general formula for basic perovskite structure is ABO_3. Perovskite is a promising photoactive material known for its higher efficiency, however poor water stability and a wide band gap limit its application for optoelectronic systems. Organic−inorganic metal halides, inorganic perovskites, oxide perovskites, lead-free perovskites, double perovskites and layered or 2D perovskites are the various types of perovskite structure [2,3]. Traditionally, lead-based perovskites have been widely employed for photovoltaic and optoelectronic devices because of their higher efficiency and low cost fabrication. However, these perovskites are very sensitive to moisture, toxic, and unstable [4]. In recent decades, lead free oxide and double perovskites have emerged as a promising alternative, offering enhanced stability and improved performance for optoelectronic devices, making them an attractive material for future technological advancements [5].

Zhang *et. al.*[6] have prepared the alcohol based double perovskite of $Cs_2AgBiBr_6$ as photocatalyst with high stability. The deposited metal clusters onto $Cs_2AgBiBr_6$ effectively enhances the photocatalytic activity. Demon et. al. have synthesized oxide-based perovskites *viz* $SrTiO_3$, $KTaO_3$, NiO-loaded $SrTiO_3$, $K_2La_2Ti_3O_{10}$, $K_4Nb_6O_{17}$, $Rb_4Nb_6O_{17}$, $Y_2Ti_2O_5S_2$ [7,8]. His group has prepared a series of materials with different doping $La_2Ti_2O_7$, $La_2Ti_2O_7$:Ba, $KLaZr_{0.3}Ti_{0.7}O_4$, $La_4CaTi_5O_{17}$, *etc* [9]. These materials exhibit higher quantum efficiency for solar light conversion. Professor Demon has fabricated the photocatalyst sheets which exhibit the highest solar-to-hydrogen (STH) conversion efficiency in the world [10].

From the literature, we found that the modified oxide and double perovskites can serve as suitable candidates to employ them as active material for the photoanode. These perovskites offer the advantage of being lead-free, addressing concerns related to toxicity and environmental impact associated with traditional lead-halide perovskites.

A fundamental motivation for selecting oxide-based perovskites in photoelectrochemical systems is because of their apparent quantum efficiency which is unity, indicating their ability to efficiently convert incident photons into charge carriers without significant energy losses. Higher apparent quantum yield suggests that these perovskites exhibit higher photocurrent density. Importantly, the band structure and electronic properties can be fine-tuned by tailoring the varying compositions. Double perovskites have spatial charge separation of photoinduced charges and reduce loss due to recombination, which significantly enhances the

performance of the device. Building on these benefits, our study is dedicated to the optimization and synthesis of oxide and double perovskites to fabricate the highly efficient, water stable and durable photoanode.

References

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Annexure-II

Detailed Water Quality Analysis of Natural Spring Water in the vicinity of IIT Mandi

1. Introduction

The Indian Himalayan Region (IHR) is the land of mountains, valleys, and water resources such as rivers, lakes, and natural water springs. This region stretches across ~2500 km from north-west to north-east. Among its many natural marvels, the Himalayan natural springs are indispensable sources of mineral-rich fresh water [1,2]. Around 30 million water spring sources provide fresh and clean drinking water to living beings [3]. Traditionally, Himalayan spring water is considered safe for direct consumption for human and animals [4,5]. However, researchers have found traces of pathogenic bacteria and harmful pollutants such as pharmaceutical waste and pesticides. The current research proposal is to develop a photoelectrochemical device to treat Himalayan spring water. However, detailed water quality parameters of springs in Himachal Pradesh is not available in the open literature. To this end, we have studied the water quality parameters of Himalayan springs in the vicinity of IIT Mandi. Kataula, Godha Farm, and School Bazar, Mandi were the model water spring sites chosen to analyse the water quality parameters. The most probable number (MPN) method was employed to analyse the microbial contamination in the water.

2. Materials and Methods

2.1 Materials

Luria-Bertani (LB) agar, MacConkey broth w/neutral red, eosin methylene blue (EMB) agar, and Brilliant green bile (BGB) broth 2% were procured for microbial testing. Standard hydrochloric acid (0.1N), phenolphthalein, methyl orange, Solochrome, ethanol, pH 10 buffer, ammonia, ammonium chloride and ethylene diamine tetra acetic acid were required for physicochemical analysis.

2.2 Methods

2.2.1 Onsite measurements and sample collection procedure

All the samples were collected on the same day, on a sunny day having moderate climatic conditions. The chance of contamination due to rain was avoided by carefully choosing the day of sample collection.

A clean beaker was rinsed three times with spring water before being filled. A calibrated, portable multi-meter was then carefully inserted into the beaker to measure temperature, pH, conductivity, total dissolved solids (TDS), and salinity. The flow rate of the water springs was obtained by measuring the time to fill the bottle (1 L). This process was repeated three times for each spring to calculate the average flow rate. Water samples were collected in PET bottles (1 L) for physicochemical analysis and autoclaved glass reagent bottles (0.5 L) for microbial testing. To prevent contamination, gloves and masks were worn during sample collection. The bottles were rinsed with spring water three times and filled up to the neck of the bottles. The cap of the bottle was properly sealed with parafilm to eliminate any contamination. The water samples were immediately kept in the refrigerator at ~4 °C. Samples from Kataula, Godha Farm, and School Bazar, Mandi were respectively labelled as S-1, S-2, and S-3.

2.2.2 Microbial test

LB agar medium was prepared by dissolving LB agar (40.0 g/L) in water, followed by autoclaving at 15 psi and 121 °C for 15 minutes. After cooling to 45-50 °C, the sterilized medium was poured into sterile

Petri plates under laminar airflow. Fixed amount (200 µL), each of the water samples (S-1, S-2, S-3) was added to the different petri plates with proper labelling. The water samples were then evenly spread over the agar surface using a sterile spreader. For comparison, autoclaved water was spread on a separate LB agar plate as a control. The prepared plates were incubated at 37 °C. After 24 hours, bacterial colonies were observed and analyzed for all samples.

Most probable number (MPN) method procedure

MPN is the most widely opted method for the screening of micro-organisms in the water and food sample [6,7]. In the present study, we have quantified the coliform and Escherichia coli (E coli) using MPN method. The following steps were performed for analysis of bacteria in the water samples:

i. MacChonkey broth (40.07g/L) was prepared in the aqueous medium and autoclaved at 15 psi, 121 °C for 15 min.
ii. Simultaneously, Durham tubes were inserted in an inverted position into test tubes, which were then autoclaved.
iii. After cooling, the sterilized media was transferred in 36 autoclaved test tubes (10 mL in each tube) in a laminar air flow hood.
iv. In three test tubes, the water sample (10 mL) was added.
v. The other three test tube sets were filled with samples S-2 (10 ml) and S-3 (10 ml).
vi. In the next 9 test tubes, 1 ml of water samples (S-1, S-2, and S-3) were added (set three test tubes per sample).
vii. 0.1 ml of water samples (S-1, S-2, and S-3) were added to the other 9 test tubes (a set of three test tubes per sample).
viii. Thereafter, 9 control test tubes were prepared by adding autoclaved deionized water: 0.1 ml in each of three test tubes, 1 ml in each of three test tubes, and 10 ml in each of three test tubes.
ix. All the test tubes were covered with cotton plugs and kept in the shaking incubator for 24 hours at 37 °C.
x. After 24 hours, the number of fermented test tubes (color change w.r.t control tubes) for each sample was compared with the standard MPN method table.
xi. The fermented test tubes were shortlisted for further analysis.
xii. EMB agar (35.96 g/L) and BGB broth (40.01 g/L) was prepared in the aqueous medium and autoclaved at 15 psi, 121 °C for 15 min.
xiii. After cooling, sterilized EMB agar was poured on the sterile petri plates in the laminar air flow. Simultaneously, BGB broth was also poured into autoclaved test tubes.
xiv. A portion of solution (100 µL) was taken from the fermented macChonkey test tubes and spread on the EMB agar plates with the help of a spreader.
xv. Simultaneously, fermented macChonkey broth media (10 µL) was added to the BGB broth test tubes and the mouths of each tube was plugged with cotton.
xvi. Prepared EMB plates were incubated for 24 h at 37 °C. BGB broth test tubes were also kept in an incubator with constant shaking.
xvii. After 24 h, bacterial colonies were observed on the EMB plates. Then, the preservation of the plates was done in the refrigerator at 4 °C.
xviii. However, no colour change was observed in the BGB broth test tubes even after the incubation of 48 h.

2.2.3 Physicochemical Measurements

The titration method was followed to measure the alkalinity and hardness of the water samples [8].

Turbidity

Turbidity was measured using a turbidimeter. The device was calibrated with different standards at 0.1, 1, and 10 NTU. The water sample was filled in a clean water container and placed in the container holder chamber. The turbidity value displayed on the digital meter was noted. The process was repeated to measure the turbidity value for all the water samples.

Phenolphthalein Alkalinity (P-Alkalinity)

The burette was rinsed with standard hydrochloric acid (0.1 N) 2-3 times, and then it was filled with the same acid by adjusting it to level zero. The, water sample (50 mL) was taken in a cleaned conical flask with the addition of 2-3 drops of phenolphthalein as an indicator. No color change has been observed for all the samples (S-1, S-2, S-3), suggesting P-Alkalinity is zero.

Total Alkalinity (T-Alkalinity)

Few drops of methyl orange as an indicator were added to the above solution. The water solution became yellowish orange. It was titrated with standard hydrochloric acid with continuous stirring until the end point became yellowish to reddish-orange.

Calculation:
Total alkalinity as $CaCO_3$ in mg/L= V1/V2 x1000
Where:-
V1= Volume in ml of standard hydrochloric acid used for titration
V2= Volume in ml of taken water sample

Hardness

The clean burette was rinsed 2-3 times with EDTA aqueous solution (0.01 N) and filled with the same solution. The level of the EDTA solution in the burette was recorded as an initial reading. The water sample (50 mL) was taken in a cleaned conical flask with the addition of buffer solution (2 mL, pH-10, 28.4 ml (NH_3) + 21.6 ml (H_2O) +3.5 g (NH_4Cl)) and 2-3 drops of Eriochrome black-T (0.5g solochrome + 50 ml ethanol). The flask was gently stirred to mix the solution. The EDTA was titrated slowly with continuously stirring till the solution changed from wine red to blue colour. Noted the final reading for the record.

Calculation:
Total hardness as $CaCO_3$ in mg/L= (V1/V2) **x**1000
Where
V1= Volume in ml of EDTA solution used for titration
V2= Volume in ml of water sample taken

3. Results and Discussion

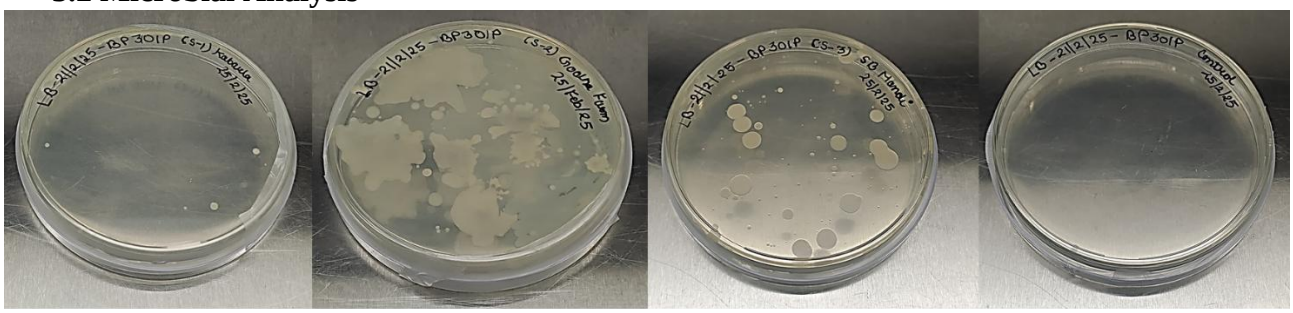
3.1 Water spring site measurements

A portable multimeter has been used to measure temperature, pH, conductivity, TDS, salinity, and average water flow rate at the spring site. The values are summarized in the Table 1.

Table 1: Temperature, pH, conductivity, TDS, salinity and average water flow rate of different water sources (S-1, S-2 and S-3).

Onsite Measurements	S-1	S-2	S-3
Temperature / ^{0}C	18	18.5	15.7
pH	7.0	7.2	7.9
Conductivity / µS	232	166	527
TDS / ppm	156	109	353
Salinity / ppm	110	78	241
Average flow rate / Ls^{-1}	14.7	14.7	39.2

3.2 Microbial Analysis

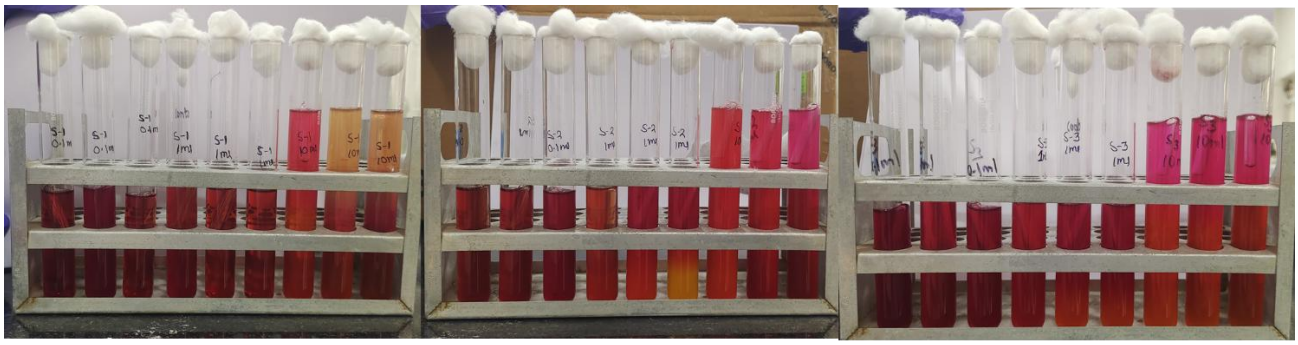


S-1 **S-2** **S-3** **Control**

Figure 1: Bacterial growth on the Luria-Bertani (LB) agar after 48 hours of incubation at 37 °C for different Himalayan spring waters.

Most probable number method

This method determines the presence of bacteria, mainly coliform and E. coli. MacChonkey broth was used as the media to identify the bacteria in the water samples. After incubation of 24 hours, the color of the media changes from red to pink, orange, and yellow. This signifies that the presence of bacteria causes the pH variation of the media to be acidic (pink), neutral (orange), and alkaline (yellow). Further indicating the presence of different bacteria such as E. coli, Klebsiella, Enterobacter, some Enterobacter spp. Salmonella, Shigella, Proteus, Pseudomonas, *etc* (Table 2). Table 3 displays the number of the fermented test tubes for different samples. The MPN/100 mL values were obtained from the MPN reference table. MPN/100 mL value for S-1, S-2 and S-3 is 7.5 (low contamination), 35 (moderate contamination) and >1100 (High contamination), respectively [9]. Type of bacteria *viz*, total coliforms in S-1, fecal coliforms, and possible E. coli S-2, Strong indication of E. coli or other fecal coliforms in S-3.



S-1 S-2 S-3

Figure 2: Fermentation of MacChonkey broth for different water source S-1, S-2, and S-3.

Table 2: Color change in MacChonkey broth

Color change	pH	Fermentation	Possible Bacteria
Pink	Acidic	Strong	E. coli, Klebsiella, Enterobacter
Orange	Neutral	Weak	Some Enterobacter spp.
Yellow	Alkaline	No	Salmonella, Shigella, Proteus, Pseudomonas

Table 3: Number of fermented (positive) MacChonkey broth test tubes at different concentration of water samples (S-1, S-2, S-3).

Sample	S-1			S-2			S-3		
10 mL	1	1	1	1	1	1	1	1	1
1 mL	0	0	1	1	1	1	1	1	1
0.1 mL	0	1	0	1	0	0	1	1	1
Obtained MPN/100 mL	7.5			35			>1100		
Reference MPN/ 100 mL	1-10			10-100			>1100		
Contamination	Low			Moderate			High		
Type of bacteria	Total coliforms			Fecal coliforms and possible E. coli			Strong indication of E. coli or other fecal coliforms		

The fermented test tubes were employed for further observation in different media such as EMB agar and BGB broth. Figure 3 demonstrated the formation of different bacterial colonies on EMB agar after 24 hours of incubation. The metallic green colored colonies, suggesting the strong lactose fermentation, confirmed the E. coli bacteria in all the water samples. Moreover, dark purple and grey colonies have also been observed with a probability indicating the presence of bacterial contamination *viz* Klebsiella pneumoniae, Enterobacter aerogenes, Salmonella, Shigella, Proteus, Pseudomonas, *etc*.

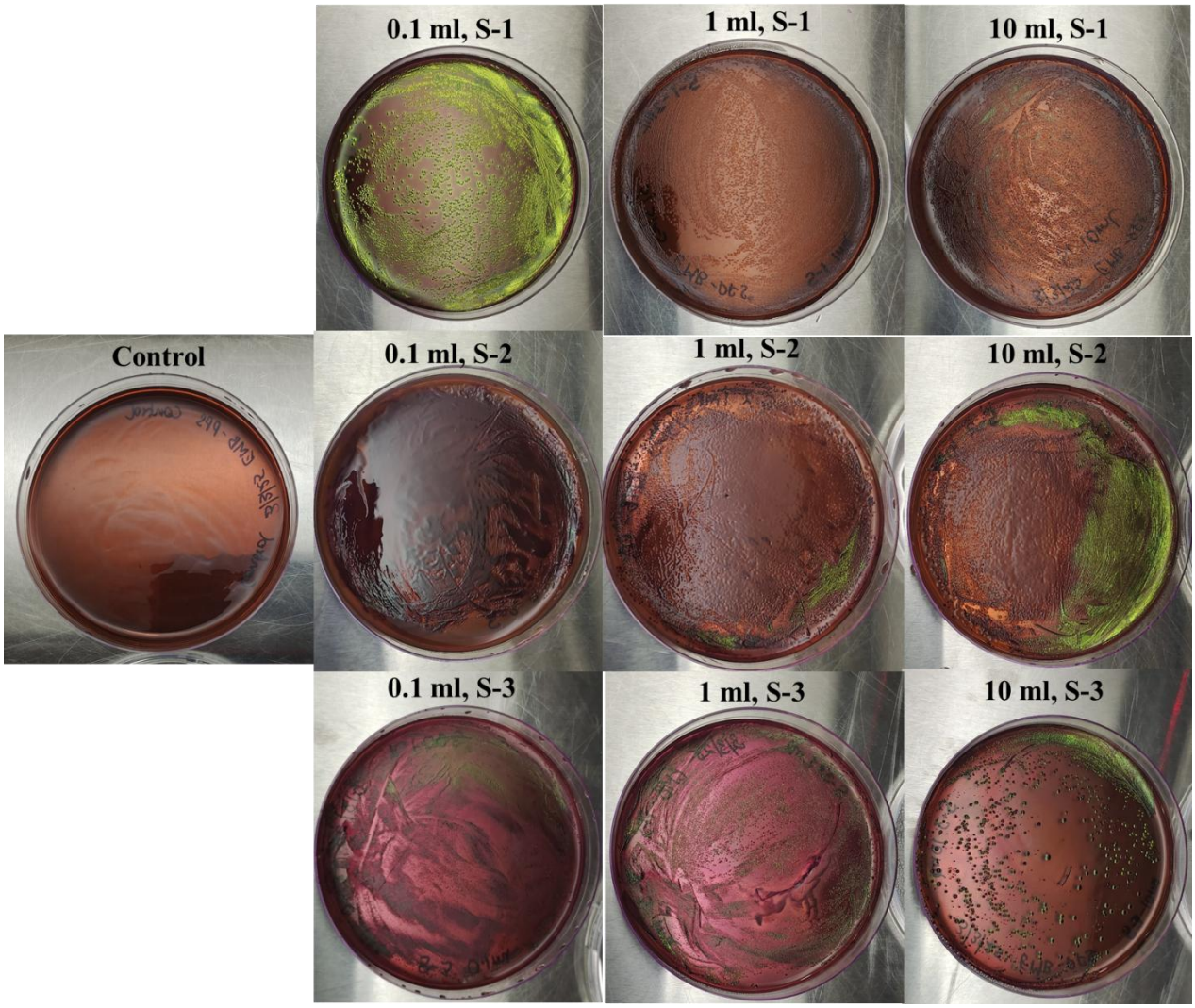


Figure 3: Bacterial growth on the EMB agar for water samples (S-1, S-2, and S-3).

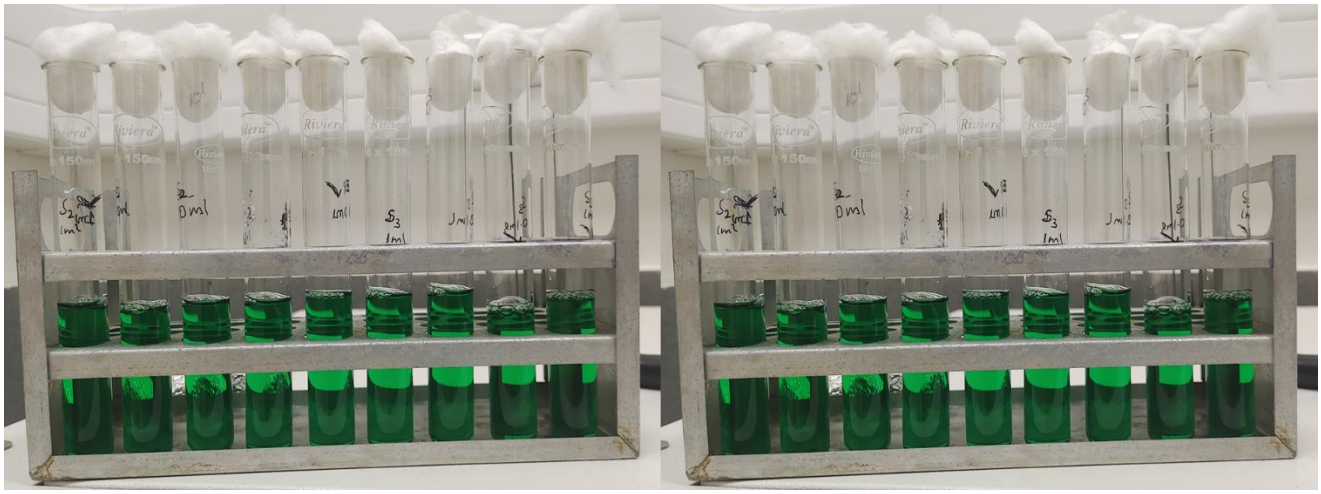


Figure 4: BGB broth with water samples (S-1, S-2, and S-3) before and after 48 hours of incubation and shaking.

No change has been observed in BGB broth even after 48 hours of incubation and shaking, suggesting no fermentation in the media.

3.3 Physical and chemical analysis

Turbidity

Turbidity is one of the most important water quality parameters, which determine the cloudiness and haziness due to the suspension of particles, organic compounds, and microorganisms. Turbidimeter was used to measure the turbidity of the water samples by detecting the scattered light from the water. The turbidity for S-1, S-2, and S-3 is 1 NTU, 0.9 NTU, and 1 NTU, respectively (Table 4). This suggests that the water sample has less turbidity and lies in the acceptable range.

Table 4: Turbidity (NTU) of water samples (S-1, S-2, and S-3)

Sample	Turbidity (NTU)
S-1	1
S-2	0.9
S-3	1
BIS standard limit	1

Alkalinity

Alkalinity of the water samples was checked by titration method. The titration results and calculation showed that P-alkalinity for all water samples is zero. Further, obtained T-alkalinity for S-1, S-2, and S-3 is 122.7, 33.3 and 218.7 mg/L. Alkalinity of S-1 and S-2 lies within acceptable limit, while alkalinity for S-3 is more than the acceptable limit.

Samples	P-Alkalinity	T-Alkalinity (mg/L)			Average Alkalinity (Acceptable limit = 200 mg/L)
		1st run	2nd run	3rd run	
S-1	0	116	116	136	122.7
S-2	0	28	24	48	33.3
S-3	0	208	228	220	218.7
BIS prescribed value					200

Hardness

To determine the hardness of the water samples, titration method was employed. S-1, S-2, and S-3 have hardness value of 137.33, 88, and 240 mg/L. Hardness for S-1 and S-2 lies within acceptable limit, while S-3 exhibit higher hardness than acceptable limit.

Samples	Hardness (mg/L)			Average hardness (Acceptable limit = 200 mg/L)
	1st run	2nd run	3rd run	

S-1	132	136	144	137.33
S-2	80	96	88	88
S-3	252	248	220	240
BIS prescribed value				200

4. Conclusion and Future Scope

The water quality analysis of Himalayan springs was successfully done and the results showed that the water from one of the sites (S-3, School Bazar, Mandi) is not safe for direct consumption. Microbial screening showed the presence of bacterial contamination such as E. coli, Klebsiella, Enterobacter, Some Enterobacter spp., Salmonella, Shigella, Proteus, Pseudomonas, *etc.* Moreover, the alkalinity and hardness of S-1 is also slightly more than the acceptable limit. The site (S-3) falls under the urban limits and hence human activities are most likely source of the observed microbial contamination. However, the moderate bacterial contamination, even from a rural site (S-2) is quite concerning.

The present research proposal is the development of the photoelectrochemical system to treat the Himalayan spring water. The water quality analysis confirmed the presence of microbial contamination in the spring water. We will selectively target these impurities and treat them with a photoelectrochemical device. Further, we will expand the scope of water quality assessment further and test more sites. We also intend to precisely identify the microbes present by advanced methods such as polymerase chain reaction (PCR). We plan to sensitise the community as well as local authorities about the contamination so that adequate measures may be taken to rectify the same.

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Annexure – III

Survey Questionnaire

Village Name: _____

1. What is your primary source of drinking water?
   - ☐ River
   - ☐ Spring
   - ☐ Borewell
   - ☐ Tap water
   - ☐ Other (specify): _____
2. How far is the main spring water source from your home?
   - ☐ < 100 meters
   - ☐ 100 – 500 meters
   - ☐ 500 meters – 1 km
   - ☐ More than 1 km
3. How is water transported to your home?
   - ☐ Piped connection
   - ☐ Carried manually
   - ☐ Other (specify): _____
4. Is there a direct connection of the water source to your home?
   - ☐ Yes
   - ☐ No
5. For what purposes do you use spring water? (Tick all that apply)
   - ☐ Drinking
   - ☐ Cooking
   - ☐ Bathing
   - ☐ Irrigation
   - ☐ Livestock
   - ☐ Other (specify): _____
6. How do you store spring water at home?
   - ☐ Open containers
   - ☐ Covered containers
   - ☐ Underground tank
   - ☐ Other (specify): _____
7. How often do you clean your water storage containers?
   - ☐ Daily

- ☐ Weekly
- ☐ Monthly
- ☐ Rarely

8. How Long you and your family have been using the spring water?
9. Have you noticed any changes in spring water availability over the years?

   If yes, what do you think are the reasons?

   - ☐ Human Activities
   - ☐ Climate change
   - ☐ Landslide or any natural calamities
   - ☐ Other (specify): _____
10. Have you noticed any seasonal changes in water quality?
    - ☐ Yes (specify: _____)
    - ☐ No
11. Do you treat water before drinking?
    - ☐ Yes
    - ☐ No
12. If **yes**, what method do you use? (Tick all that apply)
    - ☐ Boiling
    - ☐ Filtering
    - ☐ Chemical treatment
    - ☐ Other (specify): _____
13. Do you think the water quality is good?
    - ☐ Yes
    - ☐ No
    - ☐ Not sure
14. Have you noticed any changes in the color, odor, or taste of water?
    - ☐ Yes (specify: _____)
    - ☐ No

13. Have you or any family member experienced a water-related illness (diarrhea, jaundice, typhoid, etc.)?
    - ☐ Yes
    - ☐ No
14. What do you think is the possible cause of water contamination?
    - ☐ Household waste
    - ☐ Agricultural runoff
    - ☐ Animal waste
    - ☐ Natural contamination
    - ☐ Other (specify): _____

15. Approximate daily water consumption for drinking per household:

16. Have any authorities (government or NGOs) tested your water quality in the past?
    - ☐ Yes
    - ☐ No
17. Would you be willing to adopt a new water treatment method if recommended?
    - ☐ Yes
    - ☐ No
18. Any additional comments or concerns regarding drinking water quality in your village?