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Implementation of IT Tool for Centralized Water Quality Sampling Collection and Analysis

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Abstract: **The Punjab water supply and sewerage board department supplies drinking water in 62 U.L.B.'s of Punjab state. To ensure the quality of drinking water is a matter of top priority for the department to provide. With this plan to ensure good water quality, routine drinking water testing is essential to analyze various parameters of drinking water that give information about the quality of water. For this purpose, drinking water testing in the state is being done but this testing is not regular and uniform. The critical challenge in the maintaining water quality is to ensure proper sampling of drinking water, which is very difficult to standardize in the state and is the main reason or need for this study. The study came up with an innovative approach of designing an in-house centralized water quality surveillance cell situated at the head office, which monitors the sampling of drinking and wastewater and a dedicated uniform procedure with the help of I.T. as a primary tool. Each source of water and wastewater is geotagged and provides a Q.R. code, and sampling is done with the help of a mobile application. All project activities like sample scheduling, sampling, testing records are done on a live cloud-based database to minimize chances of error and reduce manual efforts by using I.T. as a power tool. With this key initiative, departmental efforts of field staff decreased considerably, and the sampling quality has improved a lot.**

Keywords**: Centralized sample collection, Q.R. Codes, Live dashboard, live reporting**

I. INTRODUCTION

Water is one of the essential elements required by all living beings to survive. Without food, humans can live for days, but survival is impossible without water. The human body contains approx 70% water, and due to a significant part of the body being of water, the quality of water we consume is essential. Many of the health problems in the body are related to the quality of water. Providing safe and healthy water to the public is one of the essential duties of every state. Providing unsafe water to the public is one of the worst acts of humankind.

In ensuring the water quality, a great effort is required in sample collection. The standardization of sample collection is a critical task. Sometimes, results reported for samples are erroneous and primarily due to the wrong sample collection procedure (1). This leads to the main reason for this study to develop a systematic uniform procedure for water sample collection, which will help ensure uniformity and reduce the extensive manual effort required for the sampling (2).

Background and Need of the Project

Punjab Water Supply and Sewerage Board (PWSSB) supplying drinking water in 62 U.L.B.'s of Punjab state. The quality of drinking water is a prime agenda for the board to provide safe and healthy water. This will ensure routine drinking water testing by analyzing various parameters to provide potable water.

For this purpose, to ensure safe water is being supplied to the public, routine tests are being done, but the board has faced the following hurdles for a long time:

- Testing for drinking water is not regular and uniform in all urban areas under Punjab Water Supply and Sewerage Board.
- Board staff, especially field staff, is busy with other works, and the water sampling area is somehow ignored.

- Lack of knowledge of field staff about proper sampling procedure, improper sample bottles, and wrong sampling procedure.
- Lack of monitoring and implementation
- Despite issuing instructions and standard operating procedures from time to time by the board, actual field implementation is significantly less.
- Water testing is being done at a local laboratory that doesn't have the proper infrastructure and testing equipment.
- A long and cumbersome procedure involving a long time for testing and reporting till then people are drinking contaminated water till results or problem comes to the knowledge of the responsible officer.

II. MATERIAL AND METHODS

Methodology and Framework of the Water Quality Monitoring System

Considering the importance of proper sampling and testing of water, the board needs a robust and sturdy system that is easy to implement and gives very fair and concise results for the actual improvement of the system. Not only should the system be developed, but it should also be able to contribute to society's betterment. The board came up with an innovative project designed and executed to make centralized water quality sampling and monitoring cells being operated from Head Office situated at Chandigarh (2). It monitors the sampling of drinking and wastewater with a dedicated uniform procedure with the help of I.T. as a critical tool (3). The critical methodology and features planned for the system are listed as below:

- Water quality sampling and monitoring system should comply with the Central Public Health and Environmental Engineering Organization (CPHEEO) Guidelines, and testing frequency shall opt-in such a way as it is practically feasible to implement in the field (4).
- A dedicated Water quality sampling and monitoring cell working independently to ensure the neutrality of results and according to proper modification and preventive steps can be taken afterward.
- A Technology-driven mobile application with a live dashboard enables the users to work quickly and accurately. The system is designed and planned according to local and seasonal conditions for better and easy implementation (3).
- An Advanced and pre-planned schedule for a quarter of the year to facilitate sample collection in the field. Systematic planning considers the capacity of the water sampling Laboratory to avoid sample traffic in the lab and cover all sources as per guidelines.
- Sample analysis and testing through water quality Laboratories of the Water Supply and Sanitation Department (NABL Labs) to ensure proper testing of water samples with uniform testing procedures (5).
- The sampling is done with different bottle types for other parameters adopting different procedures as per guidelines and standard practices (6).
- The data is being captured through Q.R. code of Samples with an in-house developed mobile app that facilitates easy and quick data capturing and negligible data entry. It helps deal with more samples in less time and minimizes chances of error while collecting the end according to the sample.
- A 24 X 7 control room, at Head Office Chandigarh well facilities Real-time monitoring of sample collection staff and their daily sampling schedule and tracking the vehicle's movement.

Planning and Identification of Sources

To begin with the project, Board started gathering data of all drinking water sources in 62 Towns where water is being supplied by the Board. They were identified as follows:

- Number of Tube wells from the 62 Towns -501Nos
- Water Treatment Plants -24 Nos
- Distribution water Points -174 Nos (*Distribution water points are points in water supply network at farthest locations to ensure drinking water quality at remotest location in city)*
- All the above mentioned sources like Tube wells, W.T.P. and distribution points are fixed with Q.R. Codes which contains all source basic information like:
  - ❖ Name of Town
  - ❖ District Details
  - ❖ Name of source
  - ❖ Q.R. Code
  - ❖ Geo coordinates of the source
  - ❖ Type of the source

These QR plates helps and facilitates easy data capturing and assigning sample details to the source with the help of Mobile App. Typical Details are shown as below

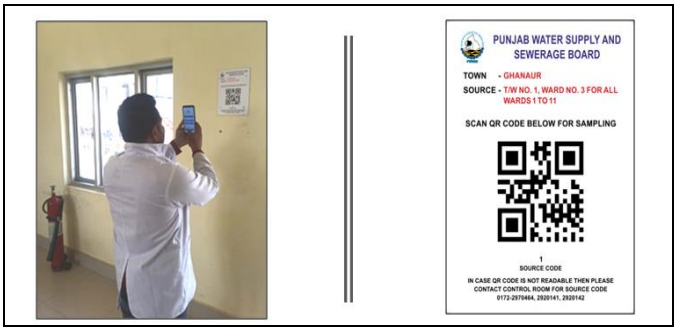


Figure 1: Depicting process of geo tagging of sources along with typical source QR Plate

Zoning and Planning of Water Sampling Schedule for Sample Collection

For sample collection by centralized teams as per the calculation of several sources, frequency of testing, and capacity of the testing lab, two water sample collection teams are purposed with their headquarters at Amritsar and Patiala, respectively. The headquarters are to be decided based on the location of the central testing laboratory so that after the

collection of samples, the samples can be deposited by clerical staff efficiently without any delay. The details of the jurisdiction of the team are also shown as under:

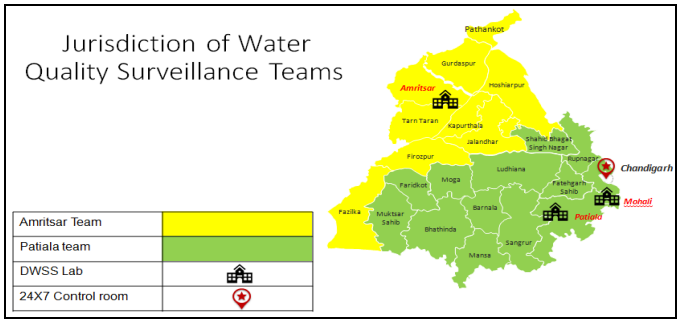


Figure 2: Depicting planning of areas of water collection teams along with Laboratory

For sample collection, a schedule is planned for all sources in consideration of CPHEEO guidelines and testing frequency (4). It shall opt so that it is practically feasible to implement in the field. The samples are divided into six categories depending on the procedure of sampling and their storage procedures as listed below (5):

SAMPLE TYPE	SAMPLING FREQUENCY	PARAMETERS
Type A	Once in quarter	Basic Parameters : pH, Turbidity, Total alkalinity , Total Hardness ,Calcium, Magnesium, Chloride , Fluoride ,Nitrate , Sulphate ,Manganese
Type B	Once in a quarter	Bacteriological : Total coliform and Faecal coliform
Type C	Once in a year	Heavy metals
Type D	Once in a year	Uranium
Type E	Once in a quarter	Field testing Residual chlorine , Turbidity pH
Type F	Once in a quarter	Waste water : BOD, COD , TSS , Faecal coliform

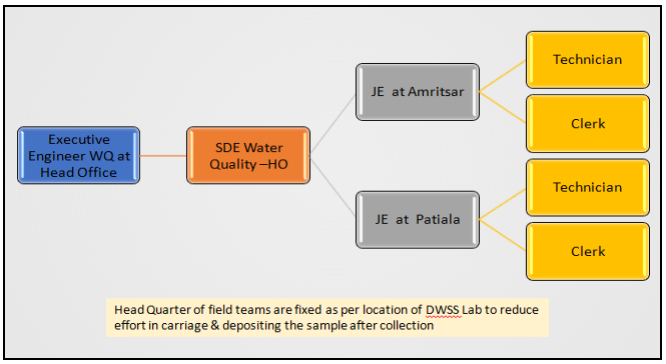
Note:- For water treatment Plant Type A,B and E parameters are tested on once a month, rest Type C and D are done once a year

For these categories, advanced scheduling in the database is done considering the following feature:

- No, of samples feasible in a day for collection by the sampling team
- Optimum routes with the shortest path in town while collecting samples
- Testing capacity at sample testing Laboratory
- Possibility of rechecking and confirmatory test to be done if required

Organizational Structure and Creating Teams for Water Sample Collection

For water sample collection purposes, it is felt that for proper implementation of the project minimum three number of team members per team comprised of Junior Engineer, Technician and clerk are required which will work under the guidance of executive engineer water quality, Head office independently to do following tasks for this project implementation as shown below:



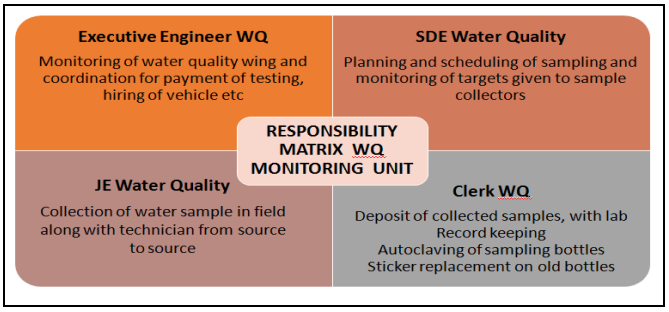


Figure 3: Depicting Institutional Setup of Water Quality Sampling Teams

Materials and Equipment Provided for Water Sampling and Collection

It is observed that in water there are various type of parameters like Basic parameters, Physical Parameters, Chemical Parameters, Bacteriological Parameters, Heavy Metals and radioactive parameters due to which sampling procedure cannot be standardized as a single procedure and for each kind of category sampling procedure, the storage and preservation method is separate.So for a single source different types of samples have to be taken for which even testing frequencies are also not uniform as per CPHEEO guide line.So for this as shown below different kinds of bottles as per sample requirements are procured, so that sampling can be done properly and each bottle is provided with a Q.R. coded sticker with a unique code which will make use of mobile app to integrate this sample with the source details so that system can be analyzed after collection as shown below:

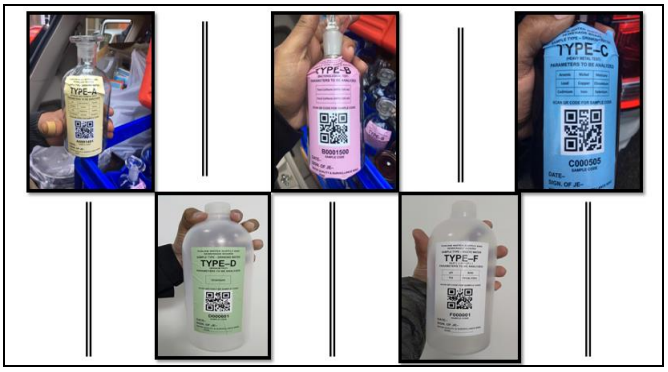


Figure 4: Various types of bottles required for the water sampling purpose

Sr no	Description	Image	Sr no	Description	Image
1	Lab Coat (Approx Cost-Rs 200/-)		9	Sample Tray (Approx Cost-Rs 400/-)	
2	Rubber Gloves (Approx Cost-Rs 80/-)		10	Ice box (Approx Cost-Rs 1250/-)	
3	Sample bottles (Approx Cost-Rs 500/-)		11	Filter Paper (Approx Cost-Rs 30/-)	
4	TDS meter (Approx Cost-Rs 500/-)		12	Auto Pipette (Approx Cost-Rs 1200/-)	
5	Chlorine testing kit (Approx Cost-Rs 350/-)		13	Measuring cylinder (Approx Cost-Rs 60/-)	
6	Blow lamp (Approx Cost-Rs 950/-)		14	pH meter (Approx Cost-Rs 950/-)	
7	Funnels (Approx Cost-Rs 40/-)		15	Turbidity meter (Approx Cost-Rs 2800/-)	
8	Nitric Acid (Approx Cost-Rs 650/-)		16	Autoclave (Approx Cost-Rs 8000/-)	

Figure 5: Various types of material and equipment required for water sample collection

Sample Collection Process and Using Mobile App Steps

For sample collection and submitting it to the Department of Water Supply and Sanitation testing lab, a robust procedure with I.T. as a critical tool is made, which is shown in the above figure and explained in steps as shown below:

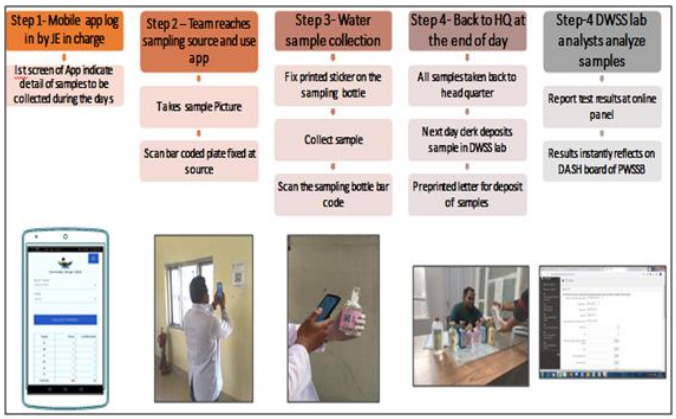


Figure 6: Depicting use of mobile app and over all sample collection process

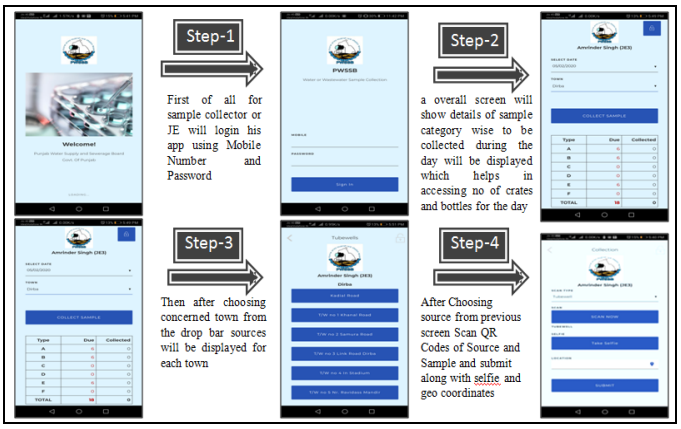


Figure 7: Depicting use of mobile app for sample collection process

Sample Submission in the Lab

To submit samples in the concerned laboratory by the sample collector, J.E. or the Clerk of the concerned team has to submit the samples for testing in the laboratory along with the pre-defined Performa already printed with duplicate copy. In this Performa, only minimum entry sample I.D. as mentioned on bottles and signature are to be mentioned as shown below:

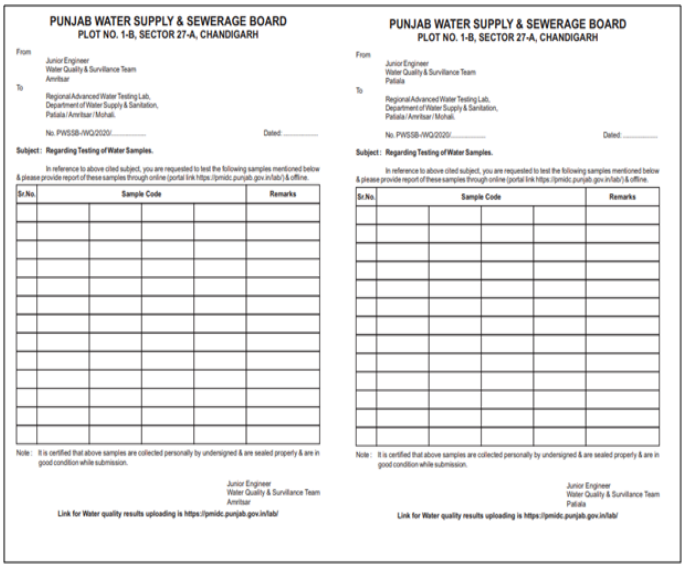


Figure 8: Depicting Format for letter in pre –printed form to be given to Lab

Sample Abalysis and Uploading in Liv Dashboard

After submission of the samples in the lab, these samples are tested by the laboratories. No details of the town, source, or division are mentioned on the sample; only sample I.D. is given, so that laboratory staff does not have any information about the sample source. After testing, the team has to upload the sample result on the dashboard through their user id and password, as shown below. After submission of the outcome, the details of the sample can be printed for record purposes

through the system, and the same will be shown in the record at dashboard instantly:

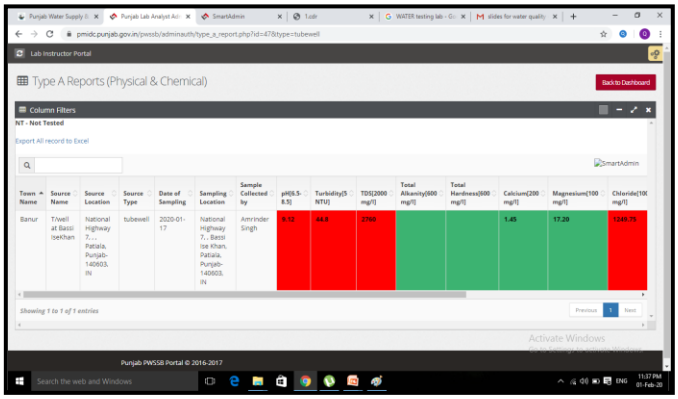
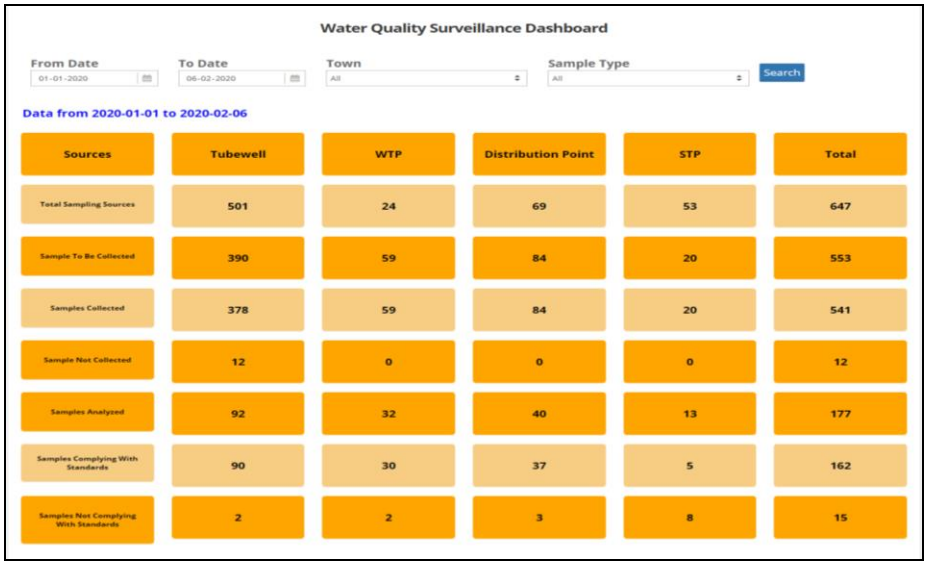


Figure 9: Login for lab uploads and result view after submission of result by lab chemist

III. Results and Discussion

Result Monitoring in Live Dashboard and Map Based Report

Result once entered is visible on the dashboard and can be monitored using various combinations of filters and date range for multiple categories of sources and also can be viewed on maps for easy understanding as shown below:



Sources	Tubewell	WTP	Distribution Point	STP	Total
Total Sampling Sources	501	24	69	53	647
Sample To Be Collected	390	59	84	20	553
Samples Collected	378	59	84	20	541
Sample Not Collected	12	0	0	0	12
Samples Analyzed	92	32	40	13	177
Samples Complying With Standards	90	30	37	5	162
Samples Not Complying With Standards	2	2	3	8	15

Figure 10: Result view at a glance in dashboard

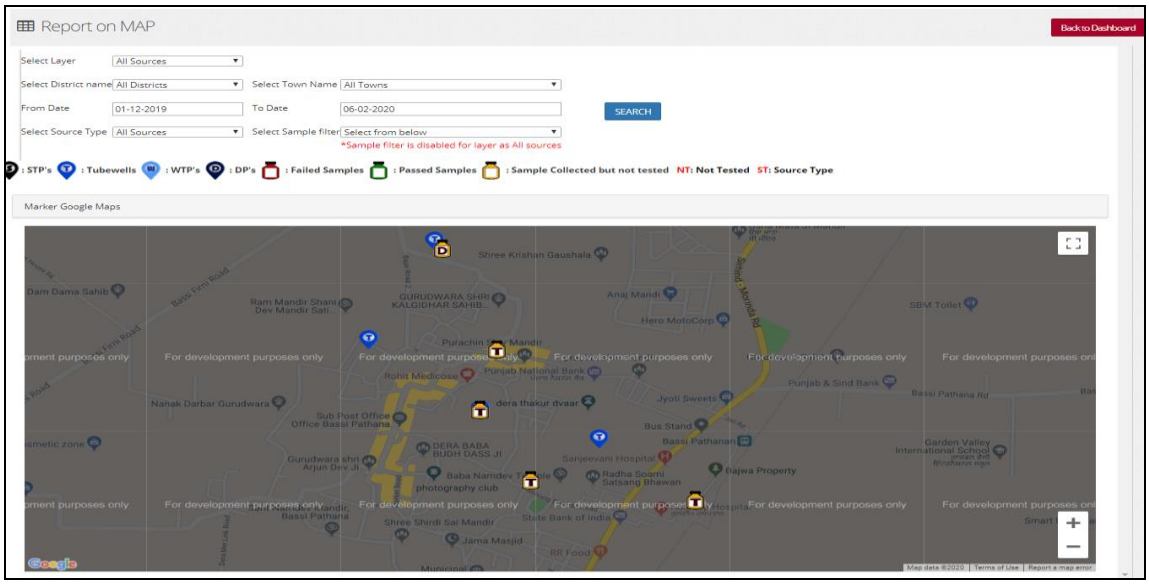


Figure 11: Result view at a glance in map for easy understanding

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Real Time Monitoring and Support through 24x7 Control Room at Head Office

For the monitoring of day to day activities of the water quality teams and their movement and sample collection status is monitored by the staff present in the control room and also the vehicle movement is also cross-checked with their daily plan using G.P.S. as shown below:

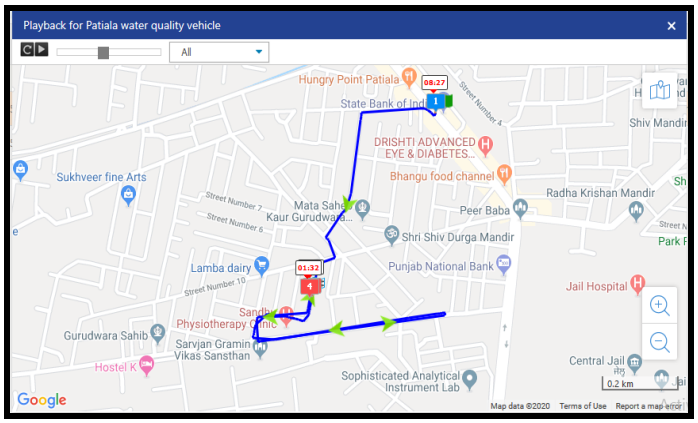

Figure 12: G.P.S. movement details of vehicle tracked by control room staff

IV. Conclusion

Outcomes and Benefits after Implementation of the System

After the implementation of the water quality sampling and monitoring system following benefits have been observed:

- Proper selection of water sources
- Adequate implementation of the CPHEEO guidelines in an effective and practical way
- Quick reporting and instant responses
- Rapid implementation of results for improvement of good quality of potable water
- Good governance reflect the excellent image of PWSSB

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