Changing Service Providers Behaviour

Study of Existing Water Quality Monitoring System, Capacity Gaps and Possibility of Effectively Functioning Model

LAAR Human Development Program
Badin

BY Amer Ejaz
www.maher.consulting

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Table of Contents

List of Acronyms

IoT	Internet of Things
INGO	InternationalNon Government Organization
KII	Key Informant Interviews
LHDP	Laar Human Development Program
MAHER	Management, Analysis and Human Empowerment for Results
NGO	Non Government Organization
PCRWR	Pakistan Council of Research in Water Resources
PHED	Public Health Engineering Department
SEPA	Sindh Environment Protection Authority
UPS	uninterruptible power supply

Proposing Model Water Quality Monitoring Mechanism

1. Introduction

As the world population continues to grow, the demand for clean and safe water increases, and ensuring access to this basic need becomes even more challenging. The situation is particularly dire in developing countries, where inadequate water infrastructure, pollution, and natural disasters often exacerbate the problem. In Badin, Pakistan, the availability and quality of water is a major concern for the district government, as the majority of the population relies on untreated surface water, and there is a lack of proper water treatment and distribution infrastructure.

To address these challenges, Laar Human Development Program (LHDP) Badin has sought the assistance of a MAHER (Management, Analysis and Human Empowerment for Results) Consulting to develop a comprehensive model for water quality monitoring. This model aims to establish a sustainable and effective system for monitoring water quality, identifying sources of contamination, and implementing corrective measures to ensure access to safe and clean water for all residents.

MAHER Consulting has conducted a thorough analysis of Badin's current water quality monitoring system, including site visits, interviews with key stakeholders, and a review of international best practices. Based on this analysis, the firm has identified several shortcomings and limitations of the current system, including a lack of collaboration between the Public Health Engineering Department (PHED), Local Government, and the Pakistan Council of Research in Water Resources (PCRWR), as well as a need for a more proactive approach to monitoring water quality.

To address these challenges, MAHER Consulting has proposed two comprehensive water quality monitoring models that utilize the latest technologies and best practices. The first model, more advanced, includes the development of an Internet of Things (IoT) platform that utilizes sensors and data analytics to monitor water quality in real-time, as well as a mobile application that allows citizens to access the latest information about water quality. The second model is a more traditional one that identifies the loopholes and deficiencies in the current practices in district Badin.

In addition to these technological solutions, MAHER has also proposed a range of capacity-building and training programs to enhance the skills and knowledge of local stakeholders, as well as stakeholder engagement and participation programs to ensure the involvement of local communities in the monitoring and management of water quality. This report provides a detailed financial breakdown for the establishment and maintenance of a water testing lab within PHED. Given the substantial setup costs, the feasibility of a separate lab seems unlikely. Consequently, it is recommended to bolster the capacity of the existing PCRWR lab in Badin with the available funding. PHED and the local government could then negotiate an agreement with PCRWR, ensuring priority and consistent testing of their samples.

Developing a comprehensive water quality monitoring and management system in Badin is critical to ensure access to safe and clean water for all residents. It is hoped that with the assistance of LHDP, the district government of Badin will take proactive steps to address this critical issue and will set an example for other communities facing similar challenges in Sindh.

2. Different Water Quality Monitoring Models Prevalent in the World

Here is a brief literature review on different models of monitoring water quality being used world over:

1. Traditional Sampling and Laboratory Testing: The traditional method of monitoring water quality involves collecting water samples from various sources, transporting them to a laboratory, and conducting tests to determine the presence and concentration of different contaminants. This method is widely used due to its accuracy and ability to detect a wide range of contaminants. However, it can be time-consuming and costly.
2. Real-time Monitoring: Real-time water quality monitoring systems use sensors to measure water quality parameters such as temperature, pH, dissolved oxygen, and turbidity. These sensors are connected to a central system that collects and analyzes data in real-time. Real-time monitoring provides continuous and immediate data, allowing for quicker response to water quality issues. However, it can be expensive to install and maintain.
3. Mobile Monitoring: Mobile water quality monitoring involves using portable equipment to measure water quality parameters in the field. This method is particularly useful for monitoring water quality in remote or hard-to-reach locations. It allows for quick and easy data collection, but the equipment can be expensive and the data collected may not be as accurate as laboratory analysis.

3. Methodology

Following are the steps taken before developing the model water quality mechanism for district Badin:

1. Site visits: Site visits were conducted to the filtration plants in each taluka to observe the water treatment process and assess the overall condition of the plants. The purpose of the visits was to identify any areas of improvement in the current system.
2. Key informant interviews (KIIs): In-depth interviews were held with staff of PHED, Local government, district administration, PCRWR, SEPA, INGOs, and academia to gather information about the current water quality monitoring system in Badin. The interviews aimed to identify the shortcomings and limitations of the current system and gather suggestions for improvement.
3. Sample testing: Water samples were collected from each taluka, including one sample each from the filtration plant, hand pump, and surface water. The samples were sent to the PCRWR lab to test physical, chemical, and microbiological parameters.
4. Review of international best practices: A review of international best practices was conducted to identify successful water quality monitoring mechanisms in other countries. The purpose of the review was to learn from the experiences of other countries and adopt best practices in the context of Badin.
5. Analysis of data: The data collected through site visits, KIIs, sample testing, and review of international best practices were analyzed to identify areas of improvement in the current system and develop recommendations for a new water quality monitoring mechanism in Badin.
6. Development of methodology: Based on data analysis, two separate models for monitoring water quality in Badin are proposed. One method is advanced and based on the Internet of Things (IoT). The second method is more traditional and is based on the collection and testing of samples regularly.The methodology included identifying water sources, sampling strategy, and frequency, monitoring water quality parameters, laboratory analysis and quality control, data management and reporting, response mechanism for water quality issues, capacity building and training, stakeholder engagement and participation, and sustainability and continuity plan. The methodology was designed to address the shortcomings and limitations of the current system and adopt international best practices in the context of Badin.

Sampling Methodology

Three samples from each taluka; one from surface water, one from hand pump and one from filtration plant.

4. Challenges and Limitations of the Current Water Quality Monitoring System in Badin

4.1 Existing Water Quality Testing Facilities

The PCRWR Laboratory in Badin stands out as the primary water quality testing facility in the region. Not only does it monitor and assess the water quality within Badin, but it also serves the neighboring districts of Sujawal, Thatta, Tando Muhammad Khan, Tharparkar, and Umerkot. Both government entities and commercial organizations, including the Public Health Engineering Department (PHED) and Badin's Municipal Administration, rely on the PCRWR Lab to test their water samples.

4.2 Assessing the Current Capacity of PCRWR, Badin Lab

The PCRWR lab in Badin is equipped to handle a comprehensive range of tests spanning chemical, physical, and biological parameters. This capacity allows the lab to thoroughly assess and monitor various aspects of water quality, from its chemical composition to its microbiological purity.

4.2.1. Chemical Analysis Capacity:

1. **UV-Visible Spectrophotometer:** It analyzes Nitrate, Iron, and Sulfate parameters.
2. **Flame Photometer:** Used to analyze Sodium and potassium parameters.
3. **Colorimeter (DR-2800):** This equipment is versatile as it analyzes various parameters, including Fluoride, Iron, Sulfate, Phosphate, Nitrate, and others.
4. **COD Spectrophotometer:** Measures the Chemical Oxygen Demand in wastewater.
5. **Others (Volumetric Titration):** Through titration, it analyzes Hardness, Calcium, Magnesium, Bicarbonate, and Chloride.

4.2.2. Physical Analysis Capacity:

1. **Conductivity Meter:** Analyzes Total Salt content (TDS) and salinity.
2. **pH Meter:** Measures the Acidity and Alkalinity of the sample.
3. **Chlorine Meter:** Used to measure Chlorine Concentration.
4. **DO Meter:** Measures the amount of Dissolved Oxygen in water.
5. **Turbidity Meter:** Measures the turbidity of a sample.

4.2.3. Biological Analysis Capacity:

1. **Incubator:** Used for the incubation of microbiological (bacterial) samples.
2. **Oven:** Useful for setting temperatures for certain parameters.
3. **Membrane Filtration Assembly:** Filters biological water samples to detect E.Coli, Fecal Coliforms, and Total Coliforms.

4.3. Operational Cost:

The current operation cost of PCRWR Badin lab is PKR 5-6 million. This includes salary of the staff, utility charges, and repair & maintenance expenses.

4.4 Assessment of Water Quality Testing Needs in Badin: Distinguishing Between Rural and Urban Areas

Ensuring access to safe drinking water is crucial for public health and well-being. For Badin, any new drinking water source must undergo rigorous quality testing prior to its establishment. Sadly, many established water sources, such as RO plants and hand pumps, have suffered damage due to inadequate maintenance, emphasizing the importance of proper oversight. This is also evident from the water testing conducted during this study. The results of these tests are placed in Annex A.

4.4.1 Uniform Challenges:

There is an observed uniformity in water quality issues across both urban and rural regions of Badin. However, the impact and consequences of these issues are unevenly distributed.

4.4.2. Rural Areas - Specific Challenges and Consequences:

a. **Knowledge Gap**:
   Rural areas have been noted to need more knowledge regarding water quality. They do not recognize the importance of regular monitoring and might unknowingly consume contaminated water.
b. **Higher Susceptibility to Water-borne Diseases**:
   Due to this lack of awareness and possibly limited access to clean water sources, rural areas see a higher incidence of water-borne diseases. Epidemics related to gastrointestinal issues, diarrheal diseases, and vibrio cholera are more frequently reported in these regions.
c. **Infrastructure Concerns**:
   Rural areas lack the robust infrastructure that urban areas might have, making it harder to implement large-scale solutions. This makes the role of individual water sources, like hand pumps, even more critical, and any damage or contamination to these can have dire consequences.

4.4.3 Urban Areas - Potential Benefits and Challenges:

a. **Better Infrastructure**:
   Urban areas generally have a better infrastructure framework, which could facilitate quicker implementation of water purification systems and solutions.
b. **Information Access**:
   Residents in urban areas have better access to information and awareness campaigns related to water quality, giving them a benefit in understanding and addressing the issue.
c. **Still at Risk**:
   Despite these advantages, the uniformity of water quality challenges means urban areas are not immune to the threats of contaminated water. Regular monitoring and proactive measures are still essential.

4.5. Recommendations:

a. **Public Awareness Campaigns**:
   Launching campaigns specifically tailored for rural areas, using local languages and relatable content, can help bridge the knowledge gap.
b. **Infrastructure Development**:
   Emphasis should be placed on developing durable water sources in both urban and rural regions, with a special focus on rural areas where the need is dire.
c. **Regular Monitoring**:
   All water sources, regardless of their location, should undergo routine checks at the PCRWR Lab in Badin to ensure they meet safety and quality standards.

While the challenges posed by water quality issues in Badin might seem uniform, the impacts differ significantly between urban and rural regions. Tailored approaches that consider these unique challenges and needs are vital for effectively addressing the district's water quality concerns.

4.6 Water Quality-Related Health Risks for Badin Citizens:

c. **Bacterial Contamination**:
   - **Primary Concerns**:
     Bacterial contamination poses a significant health risk to the residents of Badin, both in rural and urban settings.

- **Sources of Contamination**:
The proximity of drinking water sources to latrines can lead to contamination due to seepage or runoff, especially during heavy rains or flooding.
Shallow hand pumps installed on canal banks are especially vulnerable as they can easily draw in contaminated surface water.

- **Health Impacts**:
Consumption of bacterially contaminated water can lead to a host of diseases, including cholera, typhoid, and dysentery. These diseases are characterized by symptoms like diarrhea, vomiting, and severe dehydration, which, if left untreated, can be fatal, especially in children and the elderly.

b. **Saline Water Consumption**:
- **Primary Concerns**:
Badin's waters have been found to be highly saline in some areas. Regular consumption of such saline water poses long-term health risks.
- **Sources of Salinity**:
Natural processes, such as the evaporation of water bodies in arid regions, can increase salinity levels.
Human activities, like inefficient irrigation methods, can also exacerbate this issue.
- **Health Impacts**:
High saline intake is linked to high blood pressure and hypertension. Consistent exposure to saline water can strain the kidneys, leading to potential kidney diseases. An elevated salt intake can also cause swelling and fluid retention, leading to discomfort and further health complications.

c. **Chemical Contaminants**:
- **Primary Concerns**:
Apart from bacterial and saline contaminants, the presence of harmful chemicals can pose a significant risk.
- **Sources of Contamination**:
Industrial waste, agricultural runoff, and untreated sewage can introduce harmful chemicals into the water supply.
- **Health Impacts**:
Some chemicals can act as carcinogens, increasing the risk of various cancers. Others can affect the hormonal balance, reproductive health, and even lead to developmental issues in children.

d. **Heavy Metal Contamination**:
- **Primary Concerns**:
The presence of heavy metals in water sources, though often overlooked, can have severe long-term health impacts.
- **Sources of Contamination**:
Natural geological processes, as well as industrial waste and poor waste disposal practices.
- **Health Impacts**:

Heavy metals like lead, arsenic, and mercury can lead to neurological disorders, developmental issues in children, skin diseases, and a host of other health problems when consumed over time.

5. Current Model of Water Quality Testing by PHED

The current water quality monitoring model in Badin, Pakistan is inadequate and requires significant improvements. Currently, the Public Health Engineering Department (PHED) and local government only approach the PCRWR lab for testing when there is a natural calamity like floods, droughts, or excessive rains. Additionally, sometimes due to public pressure, the PHED or local government may get a sample tested[1]. However, the results are not shared with the public, and there is no regular mechanism or model to monitor the water quality in Badin.

5.1 Weaknesses in the Current Model of Water Quality Monitoring

PCRWR is currently monitoring the quality of water **periodically** as part of their program, and being a federal government organization, they mostly share their findings with their head office in Islamabad as directed. Furthermore, the same data is being shared on the National Assembly floor. The major weakness of the current water quality monitoring model is the lack of collaboration between the PHED or district government with PCRWR to highlight and mitigate issues arising from contaminated water. As such, no scientific or conventional method is developed for monitoring water quality.

5.2 Addressing Gaps in Water Quality Monitoring System in Badin

There are evident gaps in the water quality monitoring system in Badin. Addressing these gaps will require a multi-faceted approach, focusing on both capacity building within institutions and outreach to the community:

a. **Regular and systematic approach to collecting water samples:** There are several steps that can be taken to improve the water quality monitoring system in Badin. First, there should be a regular and systematic approach to collecting water samples from all major water sources in the district, including wells, tube wells, and water filtration plants. The samples should be collected based on a predetermined sampling strategy and frequency, and each sample should be analyzed for a comprehensive set of water quality parameters to monitor the quality of water.

b. **Transparency in Reporting Results:** The results of these water quality analyses should be managed and reported in a transparent and accessible manner. This can be achieved through the development of an online platform that provides real-time updates on the water quality of various sources. This platform should be accessible to the citizens and should be designed to be user-friendly, with information presented in a clear and understandable manner. Additionally, there should be a responsive mechanism for water quality issues where the public can report any issues, and the concerned authorities can take immediate action to resolve them.

c. **Community Outreach:** Community outreach is essential for effective water quality management. Awareness campaigns, leveraging local media, community meetings, and school programs, should be organized to educate residents about water quality's importance, potential health risks, and the need for regular monitoring. Moreover, it's

[1] KII with PHED official

crucial to actively involve the community in monitoring efforts, training local volunteers to collect samples, identify anomalies in water characteristics, and advocate for water hygiene practices. A robust feedback mechanism should be in place for residents to voice concerns or suggest improvements in water quality assessment. Collaborations with NGOs and civil society organizations specializing in water quality and public health can amplify outreach efforts, drive awareness, and even help secure resources. Lastly, the community should be well-informed about emergency response plans to address severe water contamination scenarios, ensuring they know the necessary steps, contacts, and how to secure safe water in such instances.

d. **Capacity Building and Training:** Another crucial aspect of improving the water quality monitoring system is capacity building and training. Training programs should be organized for the relevant stakeholders, including the staff responsible for collecting and analyzing water samples, to ensure they have the knowledge and skills to carry out their tasks effectively. Furthermore, stakeholders such as community members, NGOs, and other relevant organizations should be engaged and encouraged to participate in the monitoring and reporting of water quality issues.

6. MODEL # 1

Proposed Model Water Quality Monitoring Mechanism

(Based on the Internet of Things)

This model is based on seven interconnected steps:

6.1: Step 1: Identify the parameters to be monitored: Determine which water quality parameters need to be monitored, such as pH, temperature, turbidity, dissolved oxygen, and various contaminants.

The first step in developing an IoT model to monitor water quality in Badin is to identify the parameters to be monitored. This involves determining which water quality parameters need to be measured and tracked in order to ensure safe and clean water for consumption. These parameters could include pH levels, temperature, turbidity, dissolved oxygen, and various contaminants such as heavy metals, pesticides, and bacteria. It is important to consult with relevant stakeholders, such as public health engineering department, Local government department, PCRWR lab, NGOs and INGOs, to identify which parameters are most important to monitor in the context of Badin. Additionally, the appropriate monitoring frequency and sampling method should also be determined for each parameter. This step lays the foundation for the rest of the IoT model development process, as it ensures that all relevant water quality parameters are being measured and tracked.

Based on the sample collection from all 5 talukas of Badin, it was found that the specific parameters that need to be monitored may vary from taluka to taluka. For example, one taluka may require monitoring of pH and turbidity levels in surface water, while another taluka may require monitoring of dissolved oxygen levels in hand pumps. By testing the samples, it helped to identify the specific parameters that are most relevant to each taluka and therefore guide the selection and placement of the appropriate sensors for monitoring water quality in each location. The sample testing reports are placed at Annex A where as the summary is produced below:

Water Samples of district Badin

S.No	Sample Code	Alk.	EC	TDS	pH	Turbidity	Sodium	Potassium	Hardness	Calcium	Magnesium	Bicarbonate	Chloride	Sulfate	Nitrate	Arsenic	E Coliforms	T.Coliforms	Remarks
1	Water Supply Sche-P-111, Pond (Badin)	4.6	1013	648	7.9	2.87	104	8.5	250	66	21	230	150	55	0.1	Nil	0	280	UN-FIT
2	Civil Hosp. Badin	2.8	892	570	7.6	0	107	5	210	38	28	140	175	51	0.46	Nil	0	180	UN-FIT
3	Laghari Village, HP	5	2960	1894	7	0.97	312	19	775	152	96	250	597	375	0.8	Nil	0	0	UN-FIT
4	Water Supply Sche Pond (Matli)	4.2	869	543	8.4	1.2	99	7	210	48	22	120	135	115	1.2	Nil	0	96	UN-FIT
5	GBHSS Matli	3	319	204	7.78	0	48	5	50	16	2	50	70	9	0.1	Nil	BDL	0	FIT
6	Tal Hosp. Matli	8	2410	1542	7.14	1.98	272	5	600	92	90	400	333	312	1.38	Nil	0	48	UN-FIT
7	Water Supply Scheme, Pond T.Bago	3.6	914	584	8.32	1.6	109	8	210	40	27	180	149	64	0.1	Nil	0	81	UN-FIT
8	Misri Shah (HP) T.Bago	6.6	1810	1158	6.52	0.68	166	10	530	148	39	330	335	97	0.27	Nil	0	0	Un-FIT
9	Filter Plant T.Bago	3.6	969	620	7.95	0.87	113	7	230	44	29	180	163	71	0.1	Nil	0	28	UN-FIT
10	Tal Hosp. Golarchi	2.6	664	424	8.28	0	68	6	170	40	17	130	89.9	59	0.7	Nil	0	5	UN-FIT
11	Water Supply Pond, Golarchi	4	1023	655	8.2	0.64	111	8	260	58	28	200	156	87	0.1	Nil	0	37	UN-FIT
12	GBHS Golarchi	7	1919	1224	7.55	0.02	162	14	580	148	51	350	339	119	0.41	Nil	0	60	UN-FIT
13	Water Supply Pond, Talhar	4.2	1039	665	8.7	1.22	110	8	270	60	29	210	155	87	0.1	Nil	2	81	UN-FIT
14	GPS Talhar	2	948	606	8.28	0	123	5	180	40	19	100	155	135	0.26	Nil	0	55	UN-FIT
15	Tal Hosp Talhar	5.4	1533	981	7.6	0.9	148	15	440	95	15	270	265	110	0.8	Nil	0	340	UN-FIT
WHO Permissible Limits		NGVS	NGVS	500 (mg/l)	6.5-8.5	5 NTU	200 (mg/l)	12 EU	500 (mg/l)	NGVS	150 (mg/l)	NGVS	250 (mg/l)	250 (mg/l)	10 (mg/l)	10 (ppb)	0/100 ml	0/100 ml	

In an IoT model for water quality monitoring, rather than getting periodic samples, sensors are placed in the water source to collect data on various parameters. The sampling method involves taking continuous measurements over time, rather than periodic or sporadic measurements. This allows for a more comprehensive and accurate understanding of the water quality over time.

6.2: Step 2: Choose the appropriate sensors: Select sensors that can accurately measure the identified parameters and are suitable for use in the local environment and infrastructure.

Choosing the appropriate sensors is a crucial step in designing an effective IoT system for water quality monitoring. The selection of sensors depends on the water quality parameters identified for monitoring in step one.

It is important to choose sensors that are capable of accurately measuring the identified parameters and are suitable for use in the local environment and infrastructure. For example, some sensors may be affected by extreme temperatures or humidity, while others may not be able to withstand corrosive chemicals in the water.

When selecting sensors, it is also important to consider their accuracy, reliability, and ease of use. The cost of sensors is also a factor, as some sensors can be quite expensive.It may be necessary to consult with experts or manufacturers of water quality sensors to ensure that the selected sensors are appropriate for the specific application and environment.

In rural areas, where there may be limited access to infrastructure and electricity, solar-powered sensors or battery-powered sensors with long battery life may be more suitable. The sensors may also need to be housed in protective casing to prevent damage from animals or weather conditions. The placement of the sensors in rural areas should take into account the accessibility for maintenance and calibration.

In urban areas, power outages can also be a challenge. In such cases, backup power sources such as generators or uninterruptible power supply (UPS) systems can be used to ensure continuous power supply to the sensors. The sensors should also be placed in locations that are not prone to vandalism or theft.

In both cases, it is important to ensure that the sensors are installed correctly and securely, and that they are regularly maintained and calibrated to ensure accurate and reliable data.

6.2.1: Sensor for Monitoring Physical/Chemical Parameters

it is possible to get real-time information on the water quality of filtration plants in Badin using IoT technology. The sensors installed in the filtration plant can collect data on water quality parameters such as pH, temperature, turbidity, and contaminants. This data can be transmitted in real-time to a central system through the internet, allowing for remote monitoring and analysis. This way, stakeholders can keep track of water quality in real-time and take timely actions if any issues arise. Additionally, data can be stored for further analysis and trend analysis.

6.2.2: Sensors for monitoring microbiological parameters

Sensors are available for monitoring microbiological parameters such as total coliforms, E.coli, and other pathogens. These sensors use various methods such as fluorescence, electrochemical analysis, and impedance measurement to detect the presence of microorganisms in water. However, it is important to note that while these sensors can provide real-time information, they may not always be as accurate as traditional laboratory methods, especially for low-level detection of pathogens. Therefore, it is important to calibrate and validate the sensor data with laboratory analysis to ensure reliable results.

Calibrating sensor data with lab tests means comparing the data obtained from the sensors with the data obtained from lab tests for the same water quality parameters. This is done to ensure that the sensor data is accurate and reliable. Any discrepancies or inconsistencies between the two sets of data can be identified and corrected by adjusting the sensors or recalibrating them.

6.2.3: Reliability of Sensor Technology

Sensor technology has significantly improved in recent years, and many sensors are now reliable for measuring physical and chemical parameters such as pH, temperature, turbidity, dissolved oxygen, and various contaminants. However, the accuracy of sensor measurements can be affected by various factors such as the quality of the sensor, the environment it is placed in, and the calibration of the sensor. It is important to ensure that the sensors are calibrated regularly and maintained properly to ensure accurate and reliable data. It is also recommended to validate the sensor measurements with laboratory tests to ensure the accuracy of the data

6.2.4: Maintenance of Sensors

The maintenance of sensors typically involves the following steps:

1. Cleaning: Regular cleaning of sensors is important to prevent the buildup of dirt, grime, and other debris that can affect their accuracy. This can be done by wiping the sensors with a clean cloth or using a soft-bristled brush.
2. Calibration: Sensors need to be calibrated regularly to ensure their accuracy. Calibration involves comparing the readings from the sensor to a known standard and adjusting the sensor accordingly.
3. Replacement of parts: Over time, sensors may require the replacement of parts such as membranes, electrodes, and other components. It is important to follow the

manufacturer's guidelines for replacing parts to ensure the sensor continues to function properly.

4. Troubleshooting: If a sensor is not working properly, it may require troubleshooting to identify and fix the issue. This can involve checking the connections, power source, and other factors that could be affecting the sensor's performance.
5. Data management: It is important to keep track of the data collected by the sensors and ensure that it is stored in a secure location. This can involve using software to manage the data and ensure that it is easily accessible for analysis and reporting.

6.3: Step 3: Install the sensors at the appropriate locations, such as water sources, treatment plants, and distribution networks.

6.3.1: How to place Sensor with a Handpump

Placement of a sensor with a hand pump can be tricky, but what needs to be done is to attach the probe to the hand pump's outlet pipe.

The sensor probe typically consists of a metal or plastic rod that is inserted into the water source, and a cable that runs from the rod to the sensor device. The device itself can be mounted on a wall or placed in a protective enclosure, depending on the specific model.First, attach the probe to the outlet pipe using a bracket or clamp to install the sensor with a hand pump. This would allow the probe to be suspended in the water as it flows out of the pump. The cable would then need to be connected to the sensor device, which can be mounted nearby.

It's important to ensure the probe is positioned correctly to measure the desired parameters accurately. For example, if the water temperature is beingmonitored, the probe should be placed in the main flow of water to get an accurate reading.

Some commonly used sensors for water quality monitoring include:

1. pH sensors: to measure the acidity or basicity of the water
2. Temperature sensors: to measure the temperature of the water
3. Turbidity sensors: to measure the clarity or cloudiness of the water
4. Dissolved oxygen sensors: to measure the amount of oxygen present in the water
5. Conductivity sensors: to measure the ability of the water to conduct electricity, which is related to the concentration of dissolved salts and other ions in the water
6. Chlorine sensors: to measure the concentration of chlorine in the water, which is used as a disinfectant
7. Contaminant sensors: to detect the presence of various contaminants, such as heavy metals, pesticides, and bacteria

The data collected from these sensors can then be transmitted to a central database or server for analysis and interpretation.

To transmit the data directly from the sensor to the central office, a device such as a wireless transmitter or gateway is required to be mounted on or near the sensor. This device collects data from the sensor and then transmits it wirelessly to the central office, where it can be stored and analyzed. Alternatively, some sensors have built-in wireless capabilities, allowing them to transmit data directly without needing an additional device. In this case, the sensor must be within range of a wireless network or cellular signal to transmit the data to the central office.

In some cases, a single device may support multiple sensors by having multiple input ports or using a multiplexer to switch between sensors. In other cases, each sensor may require its own data collection and transmission device. It is important to carefully consider the requirements of the specific monitoring application and select an appropriate sensor and device setup accordingly.

> A multiplexer (MUX) is a device that selects one of several input signals and forwards the selected input signal to a single output line. It is commonly used in electronics and telecommunications to combine multiple input signals and transmit them over a single channel or wire. In the context of sensor networks, a multiplexer can be used to connect multiple sensors to a single device or to enable multiple devices to communicate with a single sensor.

6.3.2: Placing Sensor in Filtration Plant

The placement of sensors in a filtration plant depends on the specific water treatment process and the parameters that need to be monitored. However, in general, sensors can be placed at different stages of the water treatment process to monitor various parameters. For example, pH sensors can be placed at the inlet and outlet of the coagulation/flocculation tanks to monitor the effectiveness of the treatment process. Turbidity sensors can be placed at the inlet and outlet of the sedimentation tanks/ponds to monitor the efficiency of the sedimentation process. Chlorine sensors can be placed at the inlet and outlet of the disinfection unit to monitor the effectiveness of the disinfection process.

6.3.3: Placing Sensor in Reverse Osmosis Plant

In a reverse osmosis (RO) water treatment plant, sensors can be placed in various locations to monitor different water quality parameters. Here are some suggestions:

1. Feed Water: The sensor can be placed at the inlet of the RO plant to measure the quality of the feed water. The parameters that can be monitored at this point include turbidity, pH, conductivity, and total dissolved solids (TDS).
2. Pre-Treatment: Before the water enters the RO membrane, it undergoes a pre-treatment process to remove suspended solids and other impurities. Sensors can be placed in this stage to monitor the effectiveness of the pre-treatment process. The parameters that can be monitored at this point include turbidity, pH, chlorine residual, and hardness.
3. RO Membrane: Sensors can be placed at the RO membrane to monitor the performance of the membrane. The parameters that can be monitored at this point include pressure, temperature, and flow rate.
4. Post-Treatment: After the water passes through the RO membrane, it goes through a post-treatment process to adjust the pH and remineralize the water. Sensors can be placed in this stage to monitor the quality of the treated water. The parameters that can be monitored at this point include pH, alkalinity, and total dissolved solids (TDS).

The sensor placement in an RO plant may vary depending on the specific needs and design of the plant. It's important to consult with experts in water treatment to ensure the proper placement of sensors for optimal monitoring of water quality.

6.3.4: Placing Sensor for Monitoring Quality of Surface Water

Installing sensors for monitoring surface water quality typically involves the following steps:

1. Identify the suitable location: First, identify a suitable location where the sensor can be installed. This location should represent the water body being monitored and provide a good representation of water quality conditions.
2. Mount the sensor: Once the location is identified, the next step is to mount the sensor in the water. The sensor shoJuld be installed in a way that it is submerged and can continuously monitor the water quality parameters of interest.
3. Connect the sensor to a data logger: The sensor should be connected to a data logger, which collects and stores the sensor data. The data logger can be installed nearby the sensor or at a remote location.
4. Transmit data to the central office: To transmit the data to the central office, the data logger can be connected to a cellular modem, satellite transmitter or other wireless communication device.
5. Ensure regular maintenance: Regular maintenance should be conducted to ensure the sensors are functioning properly. This includes cleaning the sensor probe, replacing sensor membranes, and calibrating the sensor.

It is important to note that the specific installation process may vary depending on the type of sensor being used and the water body being monitored.

What is a Data Logger?

A data logger is a device that records data over time or in relation to location.A data logger is not the same as a sensor device. The sensor device includes the actual sensor for measuring the parameter, while the data logger is a separate device that records and stores the data from the sensor.

Whether we need a data logger depends on the type of device and its capabilities. Some sensors can transmit data directly to a central system, while others require a data logger to collect and store the data for later transmission. In cases where direct transmission is not possible, a data logger is required to collect and store the data from the sensor, and then transmit it to the central system at a later time.

6.4: Step 4: Connect the sensors to the IoT network: Establish a reliable and secure IoT network that can receive data from the sensors in real-time.

Selecting appropriate sensors and installing them, the next step is to connect them to the IoT network. This is a crucial step, enabling the sensors to transmit data in real time. The IoT network can be set up using various communication technologies, such as Wi-Fi, or cellular network, depending on the availability and reliability of these technologies in the specific area.

To ensure the reliability and security of the IoT network, it is essential to follow standard security protocols such as encryption of data, secure authentication of devices, and regular updates of the network software. This will prevent unauthorized access to the data and ensure the integrity of the system.

In rural areas with limited internet connectivity, low-power, wide-area (LPWA) technologies such as LoRaWAN and Sigfox can transmit data over long distances without a continuous power supply. In urban areas, where power outages are frequent, backup power sources such as batteries and solar panels can be used to ensure uninterrupted data transmission.

LoRaWAN (Long Range Wide Area Network) is a wireless communication protocol designed for the Internet of Things (IoT). It allows for long-range, low-power communication between IoT devices and gateways, which then relay the data to a central server. LoRaWAN operates on unlicensed radio frequencies, making it accessible to anyone with the right equipment, and is ideal for use cases where devices need to be deployed over a large area, such as smart cities, industrial monitoring, and precision agriculture. It also provides secure end-to-end encryption for data transmission.

6.5: Step 5: Data collection and analysis: Collect and analyze the data received from the sensors to monitor the water quality and identify any potential issues.

After the sensors have been installed and connected to the IoT network, the data they collect is transmitted in real-time to a central location where it can be collected and analyzed. The data collected from the sensors typically includes measurements of various water quality parameters such as pH, temperature, turbidity, dissolved oxygen, and various contaminants.

The collected data is then analyzed to identify any potential issues such as changes in water quality that could indicate contamination, or changes in water usage patterns that could indicate leaks or other problems in the water distribution system. This analysis can be done using various tools such as statistical models, machine learning algorithms, and data visualization techniques.

The collected data can also be used to generate alerts and notifications when certain thresholds or limits are exceeded, such as when the pH level of the water drops below a certain level or when the temperature rises above a certain threshold. These alerts can be sent to stakeholders such as water treatment plant operators, government officials, or even consumers.
Overall, data collection and analysis is a critical step in monitoring water quality using an IoT model. It enables stakeholders to identify potential issues early and take appropriate action to prevent or mitigate any negative impacts on public health and the environment.

6.6: Step 6:Alert and notification system: Develop an alert and notification system to inform the relevant authorities and stakeholders of any issues that require attention.

Step 6 involves developing an alert and notification system to ensure that the relevant authorities and stakeholders are informed of any water quality issues that require immediate attention. This is a crucial step in the process because it enables timely action to be taken to address any water quality issues.

The alert and notification system can be designed to send alerts and notifications via various communication channels, such as SMS, email, or mobile applications. The system can also be set up to provide alerts to specific individuals or groups based on their roles and responsibilities. For example, alerts can be sent to water quality managers or local authorities responsible for managing the water supply.

The system can be configured to trigger alerts when certain parameters fall outside of the expected range, indicating potential water quality issues. These alerts can be accompanied by contextual information, such as the location of the affected water source and the severity of the issue.

In addition to alerts, the notification system can also be used to generate reports and analytics that provide insights into water quality trends and patterns. This information can be used to proactively identify potential issues and develop strategies to address them before they become more significant problems.

6.7: Step 7: Dashboard and reporting: Develop a dashboard and reporting system that presents the collected data in a user-friendly format to enable better decision-making and policy formulation.

Step 7 involves developing a dashboard and reporting system that can provide a user-friendly view of the collected data. This step is important to enable better decision-making and policy formulation based on the water quality data collected from the sensors.

The dashboard and reporting system should be designed to present the data in an easy-to-understand format, with charts, graphs, and tables that can be customized according to the needs of different stakeholders. The system should also provide the ability to generate reports, which can be used for internal purposes or shared with external stakeholders, such as government agencies or the public.

The dashboard and reporting system can be designed to provide different levels of access and permissions to different stakeholders, depending on their needs and responsibilities. For example, government officials may need access to more detailed data and analytics, while the public may only need access to high-level summaries or alerts.

In short, the dashboard and reporting system should provide actionable insights to help stakeholders make informed decisions about water quality management and policy. It should also be regularly updated and maintained to ensure the data presented is accurate and up-to-date.

Dashboard. A visually-oriented user interface that integrates data from multiple SRS* components to provide a holistic view of distribution system water quality. The integrated display of information in a dashboard allows for more efficient and effective management of distribution system water quality and the timely investigation of water quality incidents.

*Water Quality Surveillance and Response System

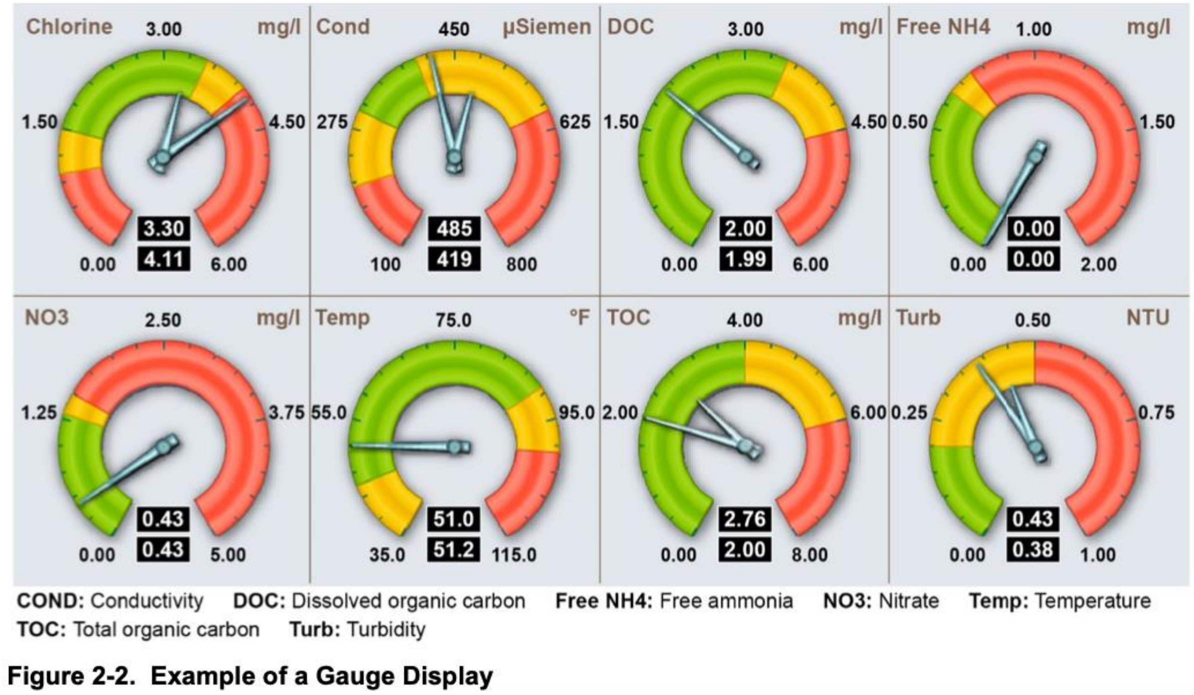

Fig 2:An example of a dashboard; Source: Dashboard Design Guidance for Water Quality Surveillance and Response System, US Environment Protection Agency, Nov 2015, p-6

6.8: Training of the Staff

Training the staff responsible for operating and maintaining the water quality monitoring system is important. This includes training on installing, calibrating, and maintaining the sensors andusing the data logging and reporting systems. Additionally, staff should be trained on how to respond to alerts and notifications and take appropriate actions to address any issues detected by the system.

Training should also cover data analysis and interpretation, as staff will need to understand and interpret the data collected by the system. This will enable them to make informed decisions and take appropriate actions to ensure that the water quality remains safe and within acceptable standards.

Regular refresher training should also be conducted to ensure that staff members remain up-to-date with the latest technology and best practices for water quality monitoring and management.

6.8.1: Training Module

The training for staff maintaining a water quality monitoring system should cover the following topics:

1. Overview of the water quality monitoring system: The staff should be familiarized with the purpose, objectives, and components of the water quality monitoring system.
2. Sensor installation and maintenance: The staff should be trained on the proper installation and maintenance of sensors, including cleaning, calibration, and troubleshooting.
3. Data collection and analysis: The staff should be trained on the data collection and analysis process, including data handling and storage, data interpretation, and identifying potential issues.

4. Alert and notification system: The staff should be trained on the alert and notification system, including the criteria for triggering alerts, the process for notifying relevant authorities, and the response plan.
5. Dashboard and reporting: The staff should be trained on the dashboard and reporting system, including accessing and interpreting the data presented.
6. Safety protocols: The staff should be trained on safety protocols, including handling chemicals and hazardous materials, and safe work practices.

The length of the training will depend on the system's complexity and the staff's level of expertise. Generally, the training should be comprehensive enough to ensure that staff members thoroughly understand the system and can effectively perform their roles. The training may be conducted over several sessions and should include hands-on practice and evaluation of staff competence.

In some cases, it may be more efficient to have one staff member trained in all aspects of the system, while in others, it may be more practical to have different staff members trained in different modules.

Ideally, each staff member should have a basic understanding of the entire system and the ability to troubleshoot any issues that may arise. However, certain staff members may require more in-depth training in specific areas, such as sensor maintenance or data analysis, depending on their roles and responsibilities.

The length of the training will also depend on the complexity of the system and the level of detail required. Basic training may take a few days to a week, while more in-depth training may take several weeks or months. Additionally, ongoing training and refresher courses should be provided to ensure that staff members are up-to-date with the latest technology and best practices.

6.9: Sustainability of the System

Sustainability is an important aspect of any system, including a water quality monitoring system. It is important to ensure that the system is designed and implemented in a way that is financially, socially, and environmentally sustainable.

Financial sustainability can be achieved by considering the system's long-term costs, including maintenance, replacement, and upgrades. Developing a funding plan that covers these costs and ensures the system's continued operation is important.

Social sustainability can be achieved by involving local communities and stakeholders in the development and implementation of the system. This can increase their ownership and involvement in the system, leading to greater acceptance and support for its continued operation.

Environmental sustainability can be achieved by using sensors and technologies that are environmentally friendly and have minimal impact on the surrounding ecosystem. It is also important to consider the potential impacts of the system on the environment and take steps to mitigate any negative effects.

7: Model # 2

A Traditional Water Quality Monitoring System based on Laboratory Testing

The second model is more traditional and is based on regular sampling and laboratory tests. Following steps are involved in this model.

7.1: Step 1: Identification of Water Sources

Identification of water sources involves identifying all potential sources of water that can be used for drinking and other purposes. This includes surface water bodies such as rivers, lakes, ponds and groundwater sources such as wells and boreholes.

The identification process should involve assessing water quality from each source and determining whether it meets the standards set by relevant regulatory authorities. Factors affecting water quality from each source, such as human activities, industrial activities, and agricultural practices, should also be considered.

Additionally, the availability, accessibility, and reliability of each water source should be assessed to determine its suitability for use as a primary or secondary source of water. This involves examining factors such as the distance from the source to the community, the volume of water available, and the cost of extracting and treating the water.

> In Pakistan, the Pakistan Environmental Protection Agency (Pak-EPA) is responsible for regulating and monitoring water quality. The agency operates under the Ministry of Climate Change and is tasked with enforcing the Pakistan Environmental Protection Act (PEPA) of 1997. Additionally, the Pakistan Council of Research in Water Resources (PCRWR) is also responsible for conducting research and monitoring water quality across the country.

7.2: Step 2: Sampling Strategy and Frequency

Once the water sources have been identified, the next step is to develop a sampling strategy to assess the water quality from each source. The sampling strategy should take into account the frequency of sampling, the number of samples to be taken, and the parameters to be tested. In order to determine an appropriate sampling frequency, it is important to consider factors such as the variability of the water quality, the type of contaminants that may be present, and the potential health risks associated with exposure to these contaminants. For example, if a water source is known to have high levels of bacterial contamination, frequent sampling may be required to ensure that the water is safe for consumption.

> Variability of water quality refers to the fluctuations or changes in the physical, chemical, and biological characteristics of water from a particular source. These variations can occur due to a variety of natural and anthropogenic factors, such as changes in weather conditions, land use activities, or industrial discharges. Therefore, it is important to monitor water quality regularly and identify any changes or trends in order to assess the potential risks to human health and the environment. A sampling strategy that takes into account the variability of water quality is essential to ensure that the collected data is representative of the actual conditions in the water source.

The sampling strategy should also consider the number of samples to be taken from each source. Generally, multiple samples should be collected from each source to ensure that the results are representative of the overall quality of the water.

Finally, the sampling strategy should identify the specific parameters to be tested in each sample. This will depend on the potential contaminants that may be present in the water, as well as any regulatory requirements for testing. Common parameters that are often tested in water samples include pH, turbidity, total dissolved solids, and various types of bacteria and other pathogens.

7.3: Step 3: Water Quality Parameters to be Monitored

Water quality parameters are the measurable characteristics used to describe the condition of water. Different parameters can be used to assess the water quality, depending on the specific water source and intended use. The selection of parameters to be monitored depends on factors such as the source of water, the intended use, and regulatory requirements.

Some of the common parameters that are monitored to assess water quality include pH, dissolved oxygen (DO), temperature, turbidity, total dissolved solids (TDS), electrical conductivity (EC), alkalinity, hardness, total suspended solids (TSS), nutrients such as nitrogen and phosphorus, chemical contaminants such as heavy metals and pesticides, and microbiological contaminants such as coliform bacteria.

The selection of parameters to be monitored should be based on a comprehensive assessment of the water source and the intended use of the water. For example, parameters such as pH, DO, temperature, and TSS are commonly monitored if the water source is a river or stream. If the water is intended for drinking, parameters such as coliform bacteria, TDS, and chemical contaminants such as arsenic and lead may also be monitored.

It is important to note that the selection of parameters to be monitored can have implications for the cost and complexity of the monitoring system. Therefore, the monitoring program should be designed carefully, and the selected parameters should be representative of the water quality issues that are of concern.

7.4: Step 4: Laboratory Analysis and Quality Control

The 'Laboratory Analysis and Quality Control' refers to the need for regular and accurate laboratory testing of water samples to ensure that the water quality meets the desired standards. This involves selecting appropriate laboratory facilities that can conduct the required tests, ensuring that the laboratory personnel are trained and qualified to carry out the testing, and implementing quality control measures to ensure the accuracy and reliability of the test results.

The laboratory analysis may include physical, chemical, and microbiological tests to measure various parameters such as pH, turbidity, dissolved oxygen, total dissolved solids, chlorine, ammonia, nitrates, heavy metals, and pathogens. Quality control measures may involve the use of certified reference materials, regular calibration of instruments, and participation in proficiency testing programs.

The results of the laboratory analysis should be recorded and reported to the relevant authorities and stakeholders, and used to inform any necessary actions to improve water quality.

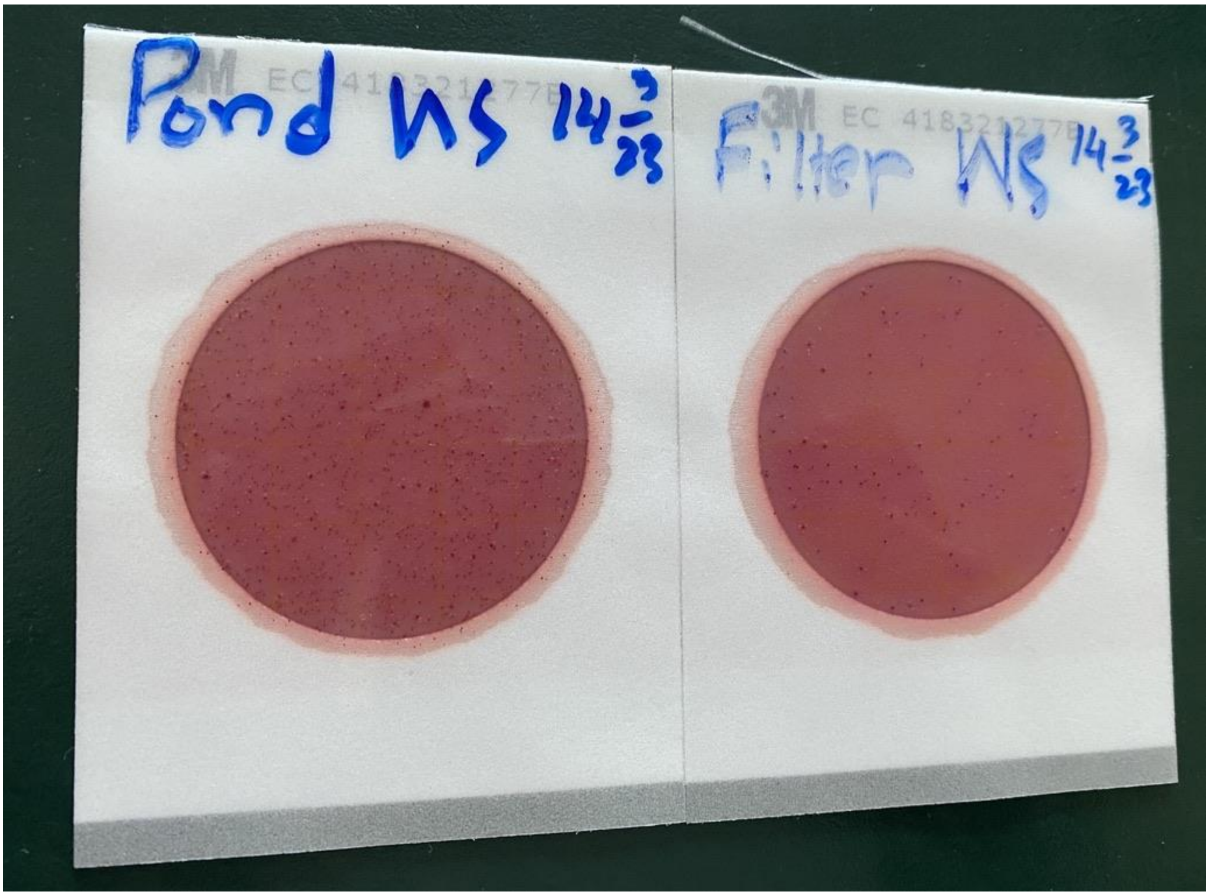

Fig 3: Testing biological parameters at PCRWR lab in Badin. In this enlarged picture, the red dots correspond to the total coliforms in a 1 ml sample taken from ponds and filtration plants. The total coliforms are TNT (Too Numerous to Count).

7.5: Step 5: Data Management and Reporting

The process of water quality management involves collecting a significant amount of data from various sources, such as sampling and laboratory analysis. The collected data must be appropriately managed, stored, and reported to ensure the effectiveness of the water quality monitoring program.

Data management involves recording all data collected and ensuring that the data is accurate, complete, and reliable. The data should be stored in a secure database and backed up regularly to avoid data loss.
Reporting involves presenting the collected data clearly and concisely that is easily understandable to decision-makers and other stakeholders. The reporting system should provide regular reports on the water quality status, including any trends or changes in the parameters being monitored.

The data management and reporting process should be efficient and effective, with a clear process for collecting, analyzing, and reporting data. The process should also be transparent, with regular communication to stakeholders regarding the status of the water quality program and any actions being taken to address issues.

Introducing the Right to Information in Monitoring Water Quality

The introduction of citizens' right to information in reporting data can be done by implementing an open data policy. An open data policy allows for the public disclosure of government data in a transparent and accessible manner. This means that citizens have the right to access and use government data without any restrictions.

To implement this policy, the government can create a centralized online platform where water quality data can be accessed and downloaded by the public. The platform should be user-friendly and accessible to all, including individuals with disabilities. The data should be presented in a format that is easy to understand and analyze.

The government can also conduct awareness campaigns to inform citizens about their right to access government data and how to access it. The campaigns can include workshops, seminars, and online tutorials. The government can also engage with civil society organizations and local communities to promote the use of open data for better decision-making and community development.The Sindh Information Commission has a pertinent role to ensure that data is proactively disclosed to the citizens.

Reactive disclosure refers to the process of releasing information in response to a specific request or incident, rather than proactively making the information available. In the context of water quality monitoring, reactive disclosure may occur when a citizen or stakeholder requests information about the water quality of a particular source, or when an incident occurs that raises concerns about water quality.

Reactive disclosure can be an important part of a comprehensive data management and reporting strategy, as it allows for timely and targeted dissemination of information to those who need it most. However, it is important to note that reactive disclosure alone is not sufficient to ensure effective water quality monitoring and management. A proactive approach that includes ongoing monitoring, analysis, and reporting is necessary to identify and address issues before they become major problems.

7.6: Step 6: Response Mechanism for Water Quality Issues

The response mechanism for water quality issues involves developing a plan to address any identified water quality problems. The plan should include specific actions to be taken, responsible authorities, timelines, and resources required for the implementation of the plan.

The response mechanism should include strategies for short-term and long-term responses. Short-term responses may involve immediate action to address the issue, such as shutting down a contaminated source of water or treating the water to remove pollutants. Long-term responses may include identifying the root cause of the issue and implementing measures to prevent it from recurring in the future.

The response mechanism should also involve coordination among different stakeholders, including government agencies, water suppliers, and the public. It is important to establish clear communication channels and protocols to ensure timely and effective response to water quality issues.

Regular monitoring and evaluation of the response mechanism should be conducted to assess its effectiveness and identify areas for improvement. This can involve regular review of water quality data, stakeholder feedback, and continuous improvement of response strategies.

7.7: Step 7: Capacity Building and Training

Capacity building and training are crucial components of any program aimed at improving water quality management. This step involves providing training and capacity-building opportunities for stakeholders such as water quality management staff, regulatory authorities, local communities, and relevant government agencies.

The training and capacity-building programs should be designed to enhance the skills and knowledge of these stakeholders in areas such as water quality monitoring, sampling techniques, laboratory analysis, data management, and reporting. The programs should also include training in using relevant technologies, such as water quality sensors and data management software.

The length and content of the training program will depend on the target audience and the program's specific needs. For instance, water quality management staff may require more technical training than those designed for local communities.

In addition to training programs, capacity-building initiatives can involve providing resources such as laboratory equipment, data management software, and technical support. This can help ensure stakeholders have the necessary resources to carry out their responsibilities effectively.

7.8: Step 8: Stakeholder Engagement and Participation

Stakeholder engagement and participation is an important aspect of any water quality management program. It involves involving and collaborating with various stakeholders, including community members, local government officials, non-governmental organizations (NGOs), and private sector representatives, to ensure that the water quality management program is effective, sustainable and meets the needs of all stakeholders.

The engagement and participation of stakeholders should occur throughout the entire water quality management process, from the identification of water sources to the response mechanism for water quality issues. This ensures that all stakeholders have a voice in the decision-making process and are aware of the progress being made in the management of water quality.

Stakeholder engagement and participation can take many forms, including community meetings, public hearings, surveys, and focus groups. These activities can help to identify the needs and concerns of stakeholders and can provide valuable input into the development and implementation of the water quality management program.

Stakeholder engagement and participation is important for building trust and credibility among stakeholders, and can help to ensure that the water quality management program is sustainable over the long term. It can also help to increase awareness of the importance of water quality, and can encourage stakeholders to take an active role in protecting and improving water quality in their communities.

7.9: Step 9: Sustainability and Continuity Plan

The final point in the traditional model for water quality monitoring is the development of a sustainability and continuity plan. This plan should ensure that the water quality monitoring system is sustainable in the long term, and that it can continue to function effectively even in the face of unforeseen events or changes in the environment.

A sustainability and continuity plan for water quality monitoring should include several key elements. First, the plan should ensure adequate financial and human resources are available to maintain the system over the long term. This may involve securing funding from government agencies, NGOs, or other sources and training and retaining qualified personnel to oversee and manage the system.

Second, the plan should include measures to ensure the water quality monitoring system is resilient and adaptable to changing conditions. This may involve periodic review and evaluation of the system to identify potential vulnerabilities and opportunities for improvement, as well as the development of contingency plans to respond to emergencies or unexpected events.

Third, the plan should incorporate mechanisms for stakeholder engagement and participation to ensure that local communities and other stakeholders have a voice in the management of their water resources. This may involve the establishment of local committees or other forms of participatory governance, as well as ongoing consultation and engagement with stakeholders to identify their needs and concerns.

Finally, the sustainability and continuity plan should be regularly reviewed and updated to ensure that it remains relevant and effective over time. This may involve periodic evaluations and assessments of the system, as well as ongoing engagement with stakeholders and other relevant actors to identify emerging challenges and opportunities for improvement.

8. Costing for Setting up the Water Quality Testing Lab

In the pursuit of ensuring water quality and safeguarding public health, an omnipresent water testing lab is of paramount importance. This comprehensive analysis deals with the multifaceted financial components involved in setting up such a facility. From procuring testing equipment to securing a conducive space, from hiring skilled personnel to ensuring a seamless operational framework, every facet demands meticulous financial planning. As we chart out the specifics, this section provides a detailed breakdown of both the initial setup costs and the recurring operational expenses. The figures outlined herein offer a transparent and holistic view, ensuring that stakeholders are well-informed of the investment needed to uphold the highest standards of water quality assessment.

8.1 Setting Up Cost

The following is the minimum cost of equipment used for water testing[2].

No	Name of the Equipment	Purpose of the equipment	Used in Which test (Physical/ Chemical/ Bio)	Approximate price of the equipment (PKR Million)
1	UV-Visible Spectrophotometer	Analysis of (Nitrate, Iron & Sulfate) Parameters	Chemical	1.5
2	Flame Photometer	Analysis of (Sodium & Potassium) Parameters	Chemical	1
3	Colorimeter (DR-2800)	Analysis of (Fluoride, Iron & Sulfate, Phosphate, Nitrate) & other Parameters	Chemical	1
4	Conductivity Meter	Analysis of Total Salts content (TDS) & Salinity	Physical	0.25
5	pH Meter	Acidity & Alkalinity	Physical	0.15
6	Chlorine Meter	Chlorine Concentration	Physical	0.15
7	DO Meter	Dissolved Oxygen in water	Physical	0. 25
8	COD Spectrophotometer	Chemical Oxygen demand in waste water	Chemical	0.3
9	Incubator	Incubation of Microbiological (bacterial) Samples.	Biological	0.80
10	Oven	Temperature setting of some parameters	Biological	0.50
11	Membrane Filtration Assembly	Filtration of Biological water samples (E.Coli, Fecal Coliforms & Total Coliforms)	Biological	0.50
12	Turbidity Meter	Turbidity	Physical	0.10

[2] Based on rapid market research.

13	Others (Volumetric Titration)	Analysis of Hardness, Calcium, Magnesium, Bicarbonate, Chloride through titration	Chemical	0.55
14	Hot plate	Heating of Chemicals	-	0.10
15	Electric Balance	Weight/Measurement	-	0.5
16	Distillation Assembly			0.5
Total				7.9
17	Miscellaneous (10%)			0.79
Total (Equipment)				**8.69**

Cost of Furniture etc

S. No.	**Description**	**Approx. Price (PKR Million)**
1	Furniture (Tables/Chairs etc)	0.5
2	Generator (5 KV)	0.25
3	Miscellaneous	0.25
4	**Total**	**1**

8.2 Recurring Cost

PCRWR does water testing for three types of parameters i.e., physical, chemical and biological. Testing water quality for these parameters involves costs other than the equipment that we mentioned above. This cost pertains to consumables like chemicals/solutions/dyes/mixtures, filters/membrane etc that are used in the test[3].

No	Test type (Physical/ Chemical/Bio)	Approx. Cost of chemical/ solutions/ dyes/mixtures per test (PKR)
1	Electrical Conductivity	300
2	Total Dissolved Solids (TDS)	300
3	pH	300
4	Turbidity	300
5	Hardness	300
6	Calcium	300
7	Magnesium	300
8	Chloride	300
9	Bicarbonate	300
10	Sulfate	350
11	Iron	350
12	Fluoride	350
13	Nitrate	400
14	Sodium	300
15	Potassium	300
16	Arsenic	1000

[3] Interview with PCRWR officials

17	Bacterial Parameters	2000
18	Dissolved Oxygen	300
19	COD Parameters	1000
20	Free & Total Chlorine	500

Operational Cost

No.	Description	Approximate Annual cost (PKR Million)
1	Personnel (one supervisor and 3 technicians)[4]	3.6
2	Office rent (@ 50,000/month)	0.6
3	Operational cost (@150,000 per month)[5]	1.8
4	Cost of testing (approx.)[6]	1
Total		**7**

The initial setup cost for a Water Quality Testing lab is PKR 9.69 million. Another PKR 7 million is required as an annual recurring cost.

[4] With a bachelor or master degree in chemistry, microbiology, Environment, or biochemistry.
[5] Including utility charges, POL, stationery and other consumables
[6] Depends upon the intensity of testing activities undertaken at the lab.

9. Recommendations for the Water Testing Model in Badin

Given the financial and logistical challenges identified, it's imperative to adopt a pragmatic approach towards water quality monitoring in Badin. Here are the recommendations based on the information provided:

a. **Initial Setup and Recurring Costs**:

The data suggests that the establishment of a new lab would require an initial investment of PKR 9.14 million, with an annual operational cost of PKR 7 million. These figures point towards a significant financial commitment.

b. **Competitive Landscape**:

With PCRWR lab already operational as a major competitor in the region, it would be challenging for PHED to establish its own lab and generate sustainable revenues solely through water testing services. Moreover, setting up an independent lab under PHED may not be sustainable for two primary reasons. Firstly, the current pricing model offered by PCRWR is subsidized, with the government absorbing the additional costs. A lab under PHED cannot operate sustainably with this pricing structure, and raising the prices would be impractical since the PCRWR lab would then serve as a direct market competitor. Secondly, the operational costs for a PHED lab amount to a substantial annual commitment of PKR 7 million. Given the current financial constraints the country is grappling with, such an investment might not be feasible.

c. **Personnel Constraints**:

The absence of technical staff within PHED to operate the new lab and the complexities tied to the recruitment process—requiring multiple stages of approval—indicate potential delays and bottlenecks in getting the lab functional.

d. **Strengthen Existing Infrastructure**:

Instead of establishing a new entity, a more efficient approach would be to invest the available funds in bolstering the infrastructure and capacity of the PCRWR lab. Such a collaboration could lead to enhanced testing capabilities and faster turnaround times. A KII with PCRWR officials reveals that the lab currently requires the following equipment:

i. Colorimeter
ii. Flame photometer
iii. Electrical Conductivity Meter.
iv. Auto Volumetric Titration burette.

The approximate price of these items is PKR 1.5 million. The addition of these types of equipment will enhance the capacity of the PCRWR lab and will reduce the cost of testing. In addition, the Atomic Absorption Spectrometer is used to analyze heavy metals like lead, arsenic, chromium, and mercury, but it can cost more than PKR 2 million. However, Badin is not a heavily industrialized area, this Spectrometer is not the immediate requirement.

e. **Contractual Arrangement**:

With such a grant provided to PCRWR lab, PHED could enter into a contractual agreement with PCRWR, ensuring that water samples from PHED are tested on priority and free of cost or at a subsidized rate for a specific period. This arrangement would provide both assurance of regular testing and cost-effectiveness.

In light of these findings, a more collaborative approach with PCRWR, emphasizing capacity building and resource optimization, seems to be the most effective and sustainable solution for PHED in ensuring water quality in Badin.

Annexure A-Water Quality Test Results (15 Samples)

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6576	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Water Supply Sch P-111 (Pond), Badin		
WQL Sample Code.	PCRWR/LAB/6576/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
11.	Color	-	-	Sensory evaluation	Colorless	Colorles:
12.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles:
13.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	1013
14.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.9
15.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	4.6
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	230
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	66
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	150
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	250
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	21
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	8.5
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	104
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	55
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	648
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	97
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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- Remarks: Found **Unsafe** for drinking purpose for highlighted parameters under prescribed standards.

Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Pakistan Council of Research In Water Resources (PCRWR)

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.com Tel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6577	**Total No. of Pages**	01
Client Name & Address	**Mr Amer Ejaz (MEHAR CONSULTING)**		
Client Sample Code	**Civil Hospital Badin**		
WQL Sample Code.	PCRWR/LAB/6577/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
16.	Color	-	-	Sensory evaluation	Colorless	Colorless
17.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
18.	Electrical Conductivity	(μS/cm)	0.2	APHA, 21st Edition	NGVS	892
19.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.6
20.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	2.8
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	140
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	38
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	175
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	210
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	28
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	5
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	107
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	51
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.48
17.	TDS	ppm	-	APHA, 21st Edition	1000	570
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	51
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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Prepared by (Lab Asst.)	[signature]	**Incharge Lab.**	[signature]

Council of Research In Water Resources (PCRWR) Pakistan

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

4

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6578	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Laghari Hand Pump		
WQL Sample Code.	PCRWR/LAB/6578/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
21.	Color	-	-	Sensory evaluation	Colorless	Colorless
22.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
23.	Electrical Conductivity	(μS/cm)	0.2	APHA, 21st Edition	NGVS	2960
24.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.0
25.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	5
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	250
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	152
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	597
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	778
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	98
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	19
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	312
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	375
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.80
17.	TDS	ppm	-	APHA, 21st Edition	1000	1894
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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Prepared by (Lab Asst.)		Incharge Lab.	

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6579	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Water Supply Scheme Pond (Matli)		
WQL Sample Code.	PCRWR/LAB/6579/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
26.	Color	-	-	Sensory evaluation	Colorless	Colorless
27.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
28.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	869
29.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.4
30.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	4.2
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	210
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	48
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	10
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	135
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	210
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	22
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	7
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	99
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	115
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	1.2
17.	TDS	ppm	-	APHA, 21st Edition	1000	543
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	67
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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- Remarks: Found **Unsafe** for drinking purpose for highlighted parameters under prescribed standards.

Prepared by (Lab Asst.)	Aziz fullah	Incharge Lab.	

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6580	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	GBHSS Matli, Filter Water		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
31.	Color	-	-	Sensory evaluation	Colorless	Colorless
32.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
33.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	319
34.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.78
35.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	1.0
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	50
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	16
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	70
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	50
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	2
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	5
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	48
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	9
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	204
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6581	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Taluka Hospital Matli		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Resul
36.	Color	-	-	Sensory evaluation	Colorless	Color
37.	Odor	-	-	Sensory evaluation	Un-Objectionable	Color
38.	Electrical Conductivity	(μS/cm)	0.2	APHA, 21st Edition	NGVS	241
39.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.1
40.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Resu
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	8.0
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	400
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	92
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	333
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	600
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	90
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	5
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	272
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	312
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	1.38
17.	TDS	ppm	-	APHA, 21st Edition	1000	154
18.	Arsenic	ppb	-	Merck Test Kit	50	05

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	10
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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- Remarks: Found **Unsafe** for drinking purpose for highlighted parameters under prescribed standards.

Prepared by (Lab Asst.)		Incharge Lab.	

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6582	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Water Supply Scheme, Tando Bago (Pond)		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
41.	Color	-	-	Sensory evaluation	Colorless	Colorles
42.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
43.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	914
44.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.32
45.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	3.6
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	180
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	40
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	149
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	210
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	27
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	8
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	109
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	64
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	584
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	116
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Council of Research In Water Resources ★ Pak...

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6583	**Total No. of Pages**	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Misri Shah Hand Pump, Tando Bago		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
46.	Color	-	-	Sensory evaluation	Colorless	Colorless
47.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
48.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	1810
49.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	6.52
50.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	6.6
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	330
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	148
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	335
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	530
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	39
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	10
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	166
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	97
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.27
17.	TDS	ppm	-	APHA, 21st Edition	1000	1158
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	**0**

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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Prepared by (Lab Asst.)	[signature]	**Incharge Lab.**	[signature]

Council of Research in Water Resources Pakistan

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

10

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6584	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Filter Plant Tando Bago		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
51.	Color	-	-	Sensory evaluation	Colorless	Colorless
52.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorless
53.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	969
54.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.95
55.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	3.6
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	180
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	44
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	163
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	230
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	29
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	7
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	113
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	71
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	620
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	51
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA:** American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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- Remarks: Found **Unsafe** for drinking purpose for highlighted parameters under prescribed standards.

Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

11

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6585	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Taluka Hospital Golarchi		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
56.	Color	-	-	Sensory evaluation	Colorless	Colorles
57.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
58.	Electrical Conductivity	(μS/cm)	0.2	APHA, 21st Edition	NGVS	664
59.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.28
60.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	2.6
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	130
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	40
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	89.9
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	170
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	17
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	6
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	68
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	59
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.7
17.	TDS	ppm	-	APHA, 21st Edition	1000	424
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	5
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Council of Research In Water Resources * Pakistan

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

1

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6586	**Total No. of Pages**	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Water Supply Pond, Golarchi		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
61.	Color	-	-	Sensory evaluation	Colorless	Colorles
62.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
63.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	1023
64.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.2
65.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	4
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	200
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	58
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	156
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	260
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	28
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	8
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	111
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	87
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	655
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	37
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

NGVS: No Guideline Value Set **WHO:** World Health Organization **APHA**: American Public Health Association, **BDL:** Below Detection Limit, QC: Quality Control **PSQCA:** Pakistan Standard Quality Control Authority, **NEQS:** National Environment Quality Standards . **TNT:** Too Numerous to Count

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- Remarks: Found **Unsafe** for drinking purpose for highlighted parameters under prescribed standards.

Prepared by (Lab Asst.)	[signature]	**Incharge Lab.**	[signature]

Council of Research in Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6587	**Total No. of Pages**	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	GBHS Golarchi		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Resul
66.	Color	-	-	Sensory evaluation	Colorless	Colorl
67.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorl
68.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	191
69.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.5
70.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Resu
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	7.0
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	35
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	14
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	33
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	58
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	51
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	14
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	16
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	11
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.4
17.	TDS	ppm	-	APHA, 21st Edition	1000	122
18.	Arsenic	ppb	-	Merck Test Kit	50	Ni

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	6
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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Prepared by (Lab Asst.)	Asadullah	**Incharge Lab.**	

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6588	Total No. of Pages	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Water Supply Scheme, Talhar (Pond)		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	Sample Receipt Date	29-03-2023
Date (s) of Analysis	30-03-2023	Reporting Date	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
71.	Color	-	-	Sensory evaluation	Colorless	Colorles
72.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
73.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	1039
74.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.7
75.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	4.2
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	210
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	60
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	15
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	155
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	270
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	29
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	8
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	110
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	87
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.1
17.	TDS	ppm	-	APHA, 21st Edition	1000	665
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	81
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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Prepared by (Lab Asst.)	[signature]	Incharge Lab.	[signature]

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	6589	**Total No. of Pages**	01
Client Name & Address	Mr Amer Ejaz (MEHAR CONSULTING)		
Client Sample Code	Govt Primary School Talhar		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
76.	Color	-	-	Sensory evaluation	Colorless	Colorles
77.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
78.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	948
79.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	8.28
80.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	2.0
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	100
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	40
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	155
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	180
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	19
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	5
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	123
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	135
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.26
17.	TDS	ppm	-	APHA, 21st Edition	1000	606
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	0

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Prepared by (Lab Asst.)	Asdullah	**Incharge Lab.**	

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
Ministry of Water Resources,

WATER QUALITY TEST REPORT

Report Serial No	**6590**	**Total No. of Pages**	**01**
Client Name & Address	**Mr Amer Ejaz (MEHAR CONSULTING)**		
Client Sample Code	**Taluka Hospital Talhar**		
WQL Sample Code.	PCRWR/LAB/657/23		
Temperature of sample °C	30.6	**Sample Receipt Date**	29-03-2023
Date (s) of Analysis	30-03-2023	**Reporting Date**	30-03-2023

PHYSICAL & AESTHETIC PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits (PSQCA, 2008)	Results
81.	Color	-	-	Sensory evaluation	Colorless	Colorles
82.	Odor	-	-	Sensory evaluation	Un-Objectionable	Colorles
83.	Electrical Conductivity	(µS/cm)	0.2	APHA, 21st Edition	NGVS	1533
84.	pH	-	0.02	APHA, 21st Edition	6.5-8.5	7.6
85.	Turbidity	NTU	0.2	APHA, 21st Edition	<5	<5

MAJOR CHEMICAL PARAMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
6.	Alkalinity	ppm	-	APHA, 21st Edition	NGVS	5.4
7.	Bicarbonate	ppm	5.0	APHA, 21st Edition	NGVS	270
8.	Calcium	ppm	2.0	APHA, 21st Edition	NGVS	95
9.	Carbonate	ppm	5.0	APHA, 21st Edition	NGVS	Nil
10.	Chloride	ppm	2.0	APHA, 21st Edition	250	265
11.	Hardness s $CaCO_3$	ppm	5.0	APHA, 21st Edition	500	440
12.	Magnesium	ppm	1.0	APHA, 21st Edition	NGVS	15
13.	Potassium	ppm	0.2	APHA, 21st Edition	NGVS	15
14.	Sodium	ppm	1.0	APHA, 21st Edition	NGVS	148
15.	Sulfate	ppm	0.4	APHA, 21st Edition	NGVS	110
16.	Nitrate (N)	ppm	0.06	APHA, 21st Edition	10	0.80
17.	TDS	ppm	-	APHA, 21st Edition	1000	981
18.	Arsenic	ppb	-	Merck Test Kit	50	Nil

MICROBIOLOGICAL PARMETERS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	Permissible Limits	Results
19.	Total Coliforms	Cfu/ml	<1	APHA, 22nd Edition	0/ml	340
20.	E. Coli	Cfu/ml	<1	APHA, 22nd Edition	0/ml	**0**

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Prepared by (Lab Asst.)	Asfullah	**Incharge Lab.**	

Council of Research In Water Resources

Address: Near DC Chowk Opposite Laar Museum Boundary Agrovil Colony Badin
Email: pcrwrbadinsindh@gmail.comTel: 0297-870727

17