Follow that Stream

A Handbook for Conducting Projects on Water Quality and Pollution

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Foreword

'Follow that Stream' focuses on creating awareness on the importance of environmental issues, especially the management of waste and pollution of streams. It includes samples of projects based on established research designs, such that students and teachers can acquire knowledge and understanding of the physical environment, the interdependency of people and all living things, and the cultural, economic and social processes which have an impact on the environment or local economy. It also provides an opportunity to develop skills to assess, evaluate, and deal with environmental issues through inquiry, application of scientific skills, scientific method, research methodology, and experiments. This can inpire young people to develop a strong affinity, love, and concern for the environment, a sense of empathy, and an appreciation and regard for all living things by actively participating and contributing in the protection and conservation of the environment.

This book is a valuable reference resource that includes sample projects for primary to higher secondary level students. It is an attempt to complement and support students to successfully carry out meaningful projects that have an impact in their daily lives, and their community. It is hoped that these projects engage students in various activities that support several school curriculum topics in science, mathematics, technology, social studies and environmental education. The techniques and skills to carry out projects learned in these samples are transferable and applicable in all fields of education.

I would like to commend the efforts of my colleagues, writers and reviewers who worked hard to create this brilliant book that is a small step, but also a meaningful leap forward in committing to preserve our environment.

I would like to wish all our teachers, students and readers a most fulfilling engagement with the exciting projects in the field of conservation of environment.

Tashi Delek!

Kinley Tenzin (PhD)
Executive Director

Acknowledgement

The Royal Society for Protection of Nature (RSPN) extends sincere gratitude to the Keidanren Nature Conservation Fund (KNCF), Japan and Japan Environmental Education Forum (JEEF) for providing the financial assistance in development of the "Follow that Stream" handbook.

Our sincere thanks to environmental professionals and specialists from RSPN, Thimphu for their valuable technical insights and assistance in the development of this handbook. We owe our gratitude to all teachers for their sincere commitment and diligent hard work in reviewing the handbook with the noble intention towards grooming an environment friendly young generation.

We would like to sincerely acknowledge the retrieval and use of ideas from various sources. We reaffirm that this book is purely for educational purposes.

Kinley Tenzin (PhD)
Executive Director

Introduction

Freshwater is one of the most valuable and scarce natural assets, essential to sustaining the lives of uncountable organisms. In Bhutan, the primary sources of freshwater are springs, streams and rivers. The freshwater from these sources are used for numerous purposes, from drinking to the production of hydroelectricity. With rapid population growth and urbanisation, the consequent environmental degradation and escalated waste generation are threatening the future of our world. In Bhutan, like any other countries, the challenges of increasing waste and its management not only exists in cities, but has also crawled into the rural areas. The rapid influx and consumption of manufactured goods in villages have increased waste production, such as plastic containers, bottles, e-wastes, chemical wastes, clothes, cans and organic wastes. These wastes often get collected in streams and rivers, essentially contaminating it. The polluted water not only cause disease but can also affect the aquatic life.

'Follow that Stream' focuses on projects that can be taken up by students on the management of waste and pollution reduction in streams. It includes samples of different projects based on research designs. The project works in schools are a mandatory fulfillment for many subjects and offered curricula. This guide is designed to support teachers and students to successfully carry out meaningful projects that will impact their daily lives, community, and the environment. To optimise learning and make it authentic, students explore, understand, and engage themselves in investigating the waste management systems in their locality. Students also acquire information on how water borne diseases spread and can be prevented, and understand the preservation and conservation of native freshwater ecosystems. The projects provide opportunity to involve themselves in various activities such as field trips, surveys, interviews, practical works, planning and report writing. These projects support several school curriculum topics in science, mathematics, technology, social studies, and environmental education. The techniques and skills to carry out projects learned from these samples are transferable and applicable in all field of education.

By carrying out these projects from primary classes to higher secondary levels, it is expected that students will become more aware of their local environment, become conscious of and responsible for their actions, identify and mitigate local environmental issues, and be a guardian and protector of our shared natural environment.

Purpose of handbook

Aim:

The aim of this handbook is to sensitise students towards an understanding of the human activities and physical processes that shape our environment, to foster care and concern for the quality of the environment and learn about the sustainable management of natural resources.

OBJECTIVES

The objectives are to:

- create awareness on the importance of the environment and environmental issues.
- acquire knowledge and understanding of the environment, the interdependence of people and all living things on the physical environment, and the cultural, economic, and social processes which impact the environment.
- develop skills to assess, evaluate, and deal with environmental issues through inquiry, application of scientific skills, scientific method, research methodology and experiments.
- develop strong affinity, love and concern for the environment, a sense of empathy, appreciation and regard for all living things and actively participate and contribute in the protection and conservation of the environment.

Project works

Hands-on learning experiences are key to the development of competencies that bind knowledge, skills, values and attitudes. Project work based on research design extensively involves hands-on learning experiences which make learning more authentic and meaningful. Project work is a learning experience in which a learner can synthesise knowledge obtained from various learning areas, process to generate new ideas and information to critically and collaboratively apply in real life situations. The project work provides opportunities to acquire new abilities, culture knowledge, evaluate ideas and apply them, and promotes independent learning. Project work includes diverse activities that involve research, surveys, modelling, videography, site visits, interviews, report writing, experimentation, etc.

Project work is characterised by the following:

1. It is learner centered that is driven by clearly defined aims and the end-product.
2. It harnesses mixed ability of learners and provides opportunities to learn something new to contribute and create new knowledge.
3. It is complex, realistic, innovative, and limited to time and space.
4. It involves team work, which provides solution to problems in specific context and time.
5. It is unique, adventurous and achievable.

The project work is essential and an effective technique where students:

- explore and extend science knowledge and skills beyond the classroom.

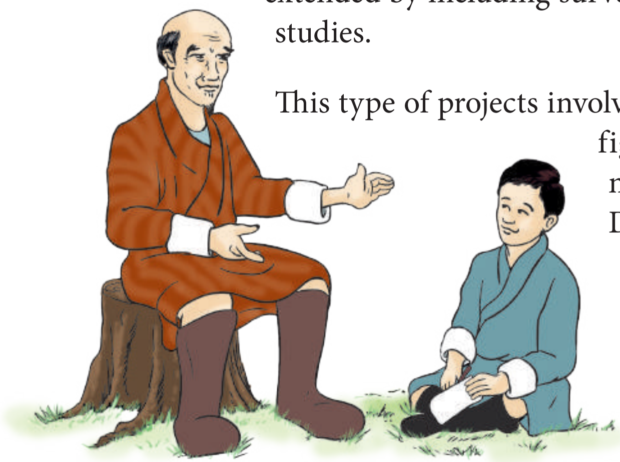
- learn to organise, plan and put together several separate ideas and information into a coherent whole.
- learn various scientific techniques and skills, including data collection, analysis, experimentation, interpretation, evaluation and drawing conclusion which fosters positive attitude towards science and environment.

The magnitude of the projects work is determined by the following aspects:

- level and age of learner.
- time and duration of project.
- subject, problem and the aim of the project.
- location and context of the project.
- resources and support available.

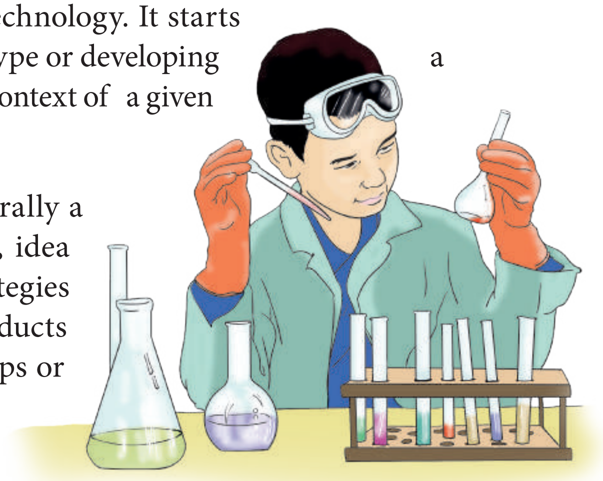
Basically, science projects based on research design and can be classified as:

Non-experimental: The project work focuses on reporting the existing situation and scenarios in a natural setting. It describes the phenomenon, such as water cycle, nutrient cycle, climate change, global warming, extinction of species and pollution in a form of a report. It relies on facts, figures and information from research already completed in addition to other sources. The project can be extended by including surveys, case studies, descriptive or correlational studies.



This type of projects involves profiling samples, information, and facts figures about specific topics or themes. It may manifest into a journal or a scrap book. Demonstration of a known scientific principle or natural phenomenon may be included in this type of project, which can also improve manipulative skills and dexterity in handling scientific equipment and apparatus. It may demand innovation and drawing on relevant and effective analogies for understanding certain phenomenon.

Experimental: This is the type of project may be carried out to verify theories, laws, reactions, phenomenon and events that are not possible in natural settings. The variables are manipulated and creating a fair test is emphasised. The hypothesis is proved or disproved and then reported. This type of project generally involves designing models, methods of measurement, analyzing and improving on the construction of a device, material or technology. It starts with model designing, building a prototype or developing a simulation to test its effectiveness in the context of a given situation, material, and application.



The output of the project work is generally a tangible product, prototype or model, idea or concept, plan, and they include strategies for implementation, and/or digital products like video, simulation, software and apps or documents, accompanied by a report.

About this handbook

This handbook is designed to illustrate the processes involved in carrying out projects in schools with regards to the local environment. It includes samples, topics and ideas for primary to higher secondary level students. The project samples are aimed to provide guidance in order to carry out project work in school, as a mandatory fulfillment of the course. Ideally, this handbook can impart enough confidence and skills to carry out projects on any topic and subject area. There are three sample projects for grade IV to VI, two samples for grade VII to VIII students, and two samples for grade IX to XII students. The sample projects for different levels are clearly defined by the nature of issue, depth and vigorousness, and extent of the project. The knowledge, skill and competencies are gradually developed and strengthened as we carry out the projects from primary to secondary level. Each sample project includes writing frames and follows the scientific method to investigate and address environmental issues.

Grade IV and VI level project samples are simple yet meaningful topics concerning the quality of drinking water, pollution of local streams and how to save water. At this stage, the project is small in magnitude with short write-ups and includes simple experiments. The whole focus is to create awareness, and develop an affinity towards and concern for the environment, besides developing both scientific communication and collaboration skills.

Grade VII and VIII level project samples illustrate progression on the requirement of knowledge, skills and competencies. These projects create awareness on water borne diseases and the solid waste management system. Students investigate environment health status in their locality and design mitigation plan.

Grade IX to XII level projects display the requirement for complex inquiry. It involves a lot of practical works, observation, sampling, data collection and analysis. The projects build the foundation for any scientific research work in higher studies and specialisations. The sample projects execute water quality testing and determine health of the stream.

This handbook is explicitly illustrated to aid students in carrying out the project effectively. General safety, specific safety and precautions for each experiment and process are also mentioned. The annexure provides basic steps to make some of the tools required in the projects using simple household materials.

Scientific method

Definition

It is a problem-solving process to find a solution to a problem. It involves asking meaningful questions and conducting careful investigations.

The basic steps of the scientific method are:

Step 1. Observe the world around you– Making observations and identifying problems

Step 2. Discover the problem and what is known – Background research

Step 3. State what needs to be proven – Forming hypothesis

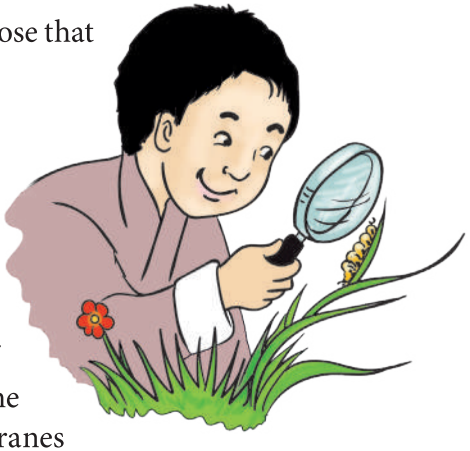
Step 4. Plan what needs to be done – Planning and procedures

Step 5. Conduct experiment and record – Testing hypothesis

Step 6. Interpret data and findings – Analyse findings

Step 7. Summarise the findings - Draw conclusion

Step 1
Observe your world around



Take a look at things and events around you. Identify those that makes you ask these questions:

- does something make you curious?
- does something seem strange to you?
- do you wonder what causes something? or
- why something happens?

Make observations by paying special attention to things that catches your attention and ask lots of question about it. For example: Ask yourself; Why is the sky orange in the evening? Why do the Black-necked Cranes fly south during winter? What makes soda fizzy? Is our drinking water safe and clean? Why do students suffer from diarrhoea frequently?

By this step you should find something that really interests you the most and that you would like to find out more about it, or it could be a problem or an issue that needs solutions.

Step 2
Discover what is known about the problem

It is extremely important to begin with a concrete problem or a question. Go through a wide variety of resources and collect as much information as possible on the problem. Resource materials can be books, journal articles, newspapers, magazines, science videos and websites.

Choose a problem for which you do not know the answer and a problem that you can work with. State the problem in the form of a question. A good question should lead to solutions that can be tested, measured and analysed. Collect more information on the problem which will help you develop the procedure, method of data collection, plan experiments or tools.

Step 3
State what needs to be proved

Guess a possible solution or an answer to your problem or question. It is called a hypothesis. Developing a good hypothesis is the most difficult step of the scientific method. The hypothesis is the centre of your project. If the hypothesis does not make sense, the whole project will not make sense. When forming the hypothesis, write a simple statement. Make it precise and measurable. The hypothesis is based on the defined problem and the information collected. It proposes a solution to your problem. Therefore, if your hypothesis is proved, then your question is answered.

Step 4
Plan what needs to be done

During this phase, decide on the best approach to test your hypothesis and solve your problem. Choose whether experimentation is required to test your hypothesis. If yes, write down the procedures that will be used to test your experiment.If no experiment is involved, select effective means of observations and collection of data. Writing your procedures will help you to:

- gather necessary materials.
- experiment or apply a method that fits the hypothesis being tested
- repeat the experiment or steps if required.

Carefully plan how the variables will be observed and analysed. There are three types of variables that you need to consider when designing your observation and data collection method: independent variables, dependent variables, and controlled variables. Independent variables are the things or factors you can change in your experiment or that you can vary to observe its influence. The independent variable can be kept the same or constant throughout the study or experiment. The term is called controlled variable. A dependent variable is the thing you measure whenever you change the independent variable, and your control variables are the factors that you keep constant in each run of your experiment.

Step 5
Conduct experiment and record

Now, the focus is to carry out the procedure and test your hypothesis. If the preferred conditions are not found in natural settings, then an experiment can be set up. Most of the experiments are conducted in a laboratory in a controlled environment and therefore, better results are often achieved. There must be one experimental and one comparison or control group. The variables are manipulated and sample or subject is treated, while the control group is a group that does not receive the treatment.

Some observations are to be made in natural settings and variables are not deliberately manipulated, nor is the setting controlled.

Data can be quantitative (a value that can be measured or counted) or qualitative (a value that can be described but cannot be measured in terms of numbers). Some projects may combine both forms of data.

Whichever kind of data that is collected, you must be certain to record all results of your tests and observations. Recording everything as it happens will not only

help to keep your information in one place, but also minimises errors. In non-experimental design, it is important to obtain data from an appropriate sample size. Sample size is the number of subjects you test. Your sample size must be large enough to allow you to draw accurate conclusions from your data. Similarly, multiple trials data are very useful in experimental designs. This means each test should be performed several times. If one observation data widely differs from the rest, it indicates the error, so it is wise to figure out what went wrong at this point.

You need to be as accurate as possible in taking measurements while conducting experiments. It is almost impossible to measure something with perfect accuracy, so you must take the measurement more than once and then use the average of the results. This approach helps to account for the uncertainty of each individual measurement. It is crucial to double check the measurements taken before recording. The other measurement factors like observation methods, units of measurement, and instrument used must be consistent for successive recordings.

Step 6
Analyse and interpret data

Before we make sense of the data and analyse them, validations and confirmation of quality data is a must. The following steps are carried out to confirm it.

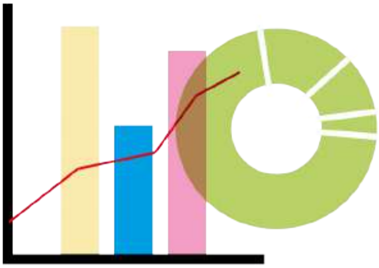
Step 1. Review all of the data collected from your experiment for consistency and accuracy.

Step 2. Check whether anything has been forgotten to be observed.

Step 3. Ensure no mistakes have been made while collecting data.

Step 4. Confirm no more data is required or data collected is enough.

Even when good data is obtained, sometimes it can be difficult to draw conclusions from it directly. Therefore, the data may be represented in the form of graphs and charts to understand the trends, relationships and patterns or calculations carried to draw and understand the desired results. Displaying the data in a chart or graph makes it easier to understand the relationship between the variables that influence the study. Knowing about different types of graphs and charts will help you to decide the best way to illustrate data, before making the final graphs and analysis.



Two experiments may have the same average result, but will differ in how the results are distributed. If the results are mathematical, it will help you to understand the concepts of mean and median. Mean is the average of your data, and median is the middle-most value when all measurements are listed in order from smallest to largest. Compare the means and medians and see how they differ. All the calculations are done during analysis.

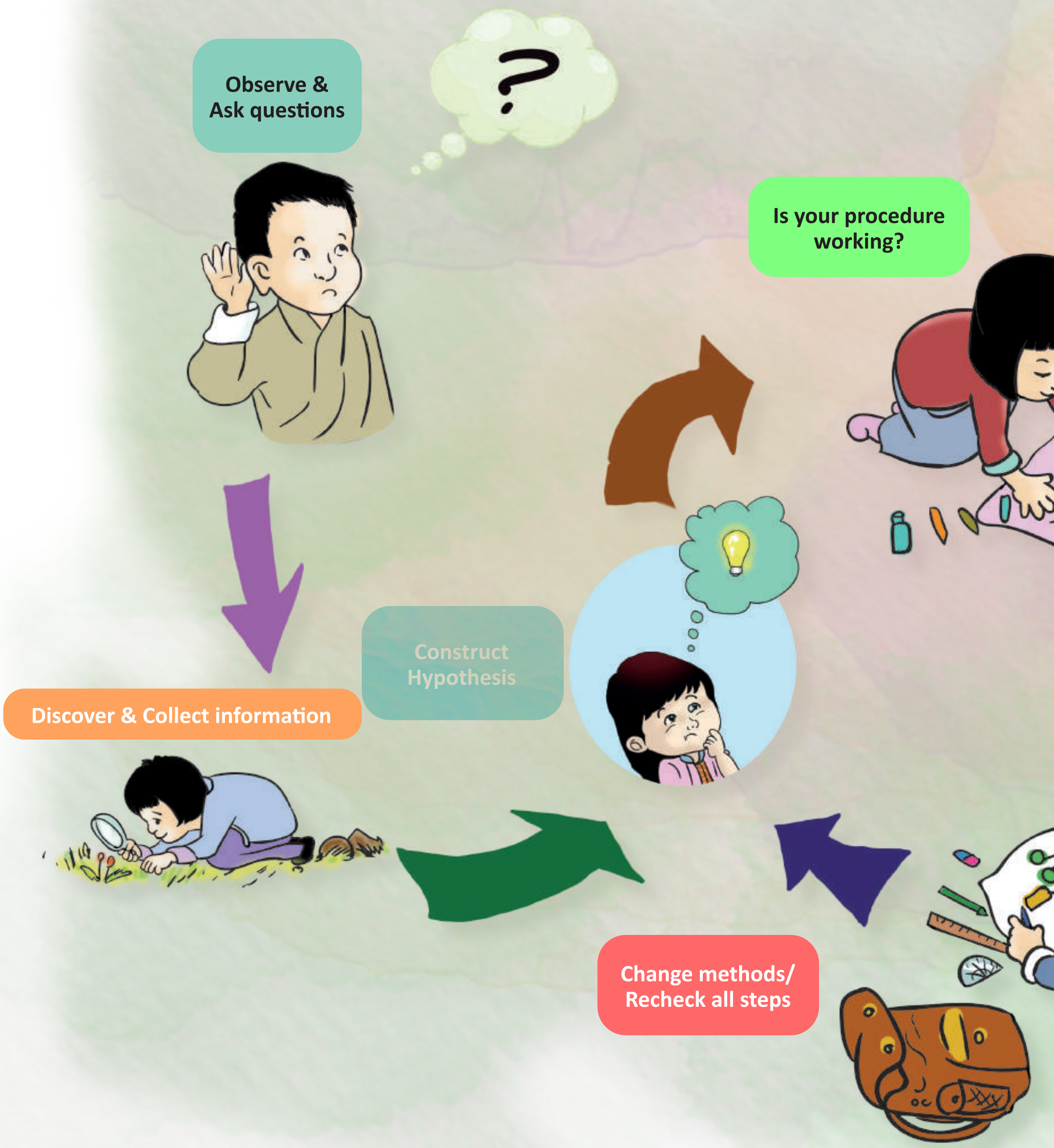
Step 7
Summarise findings

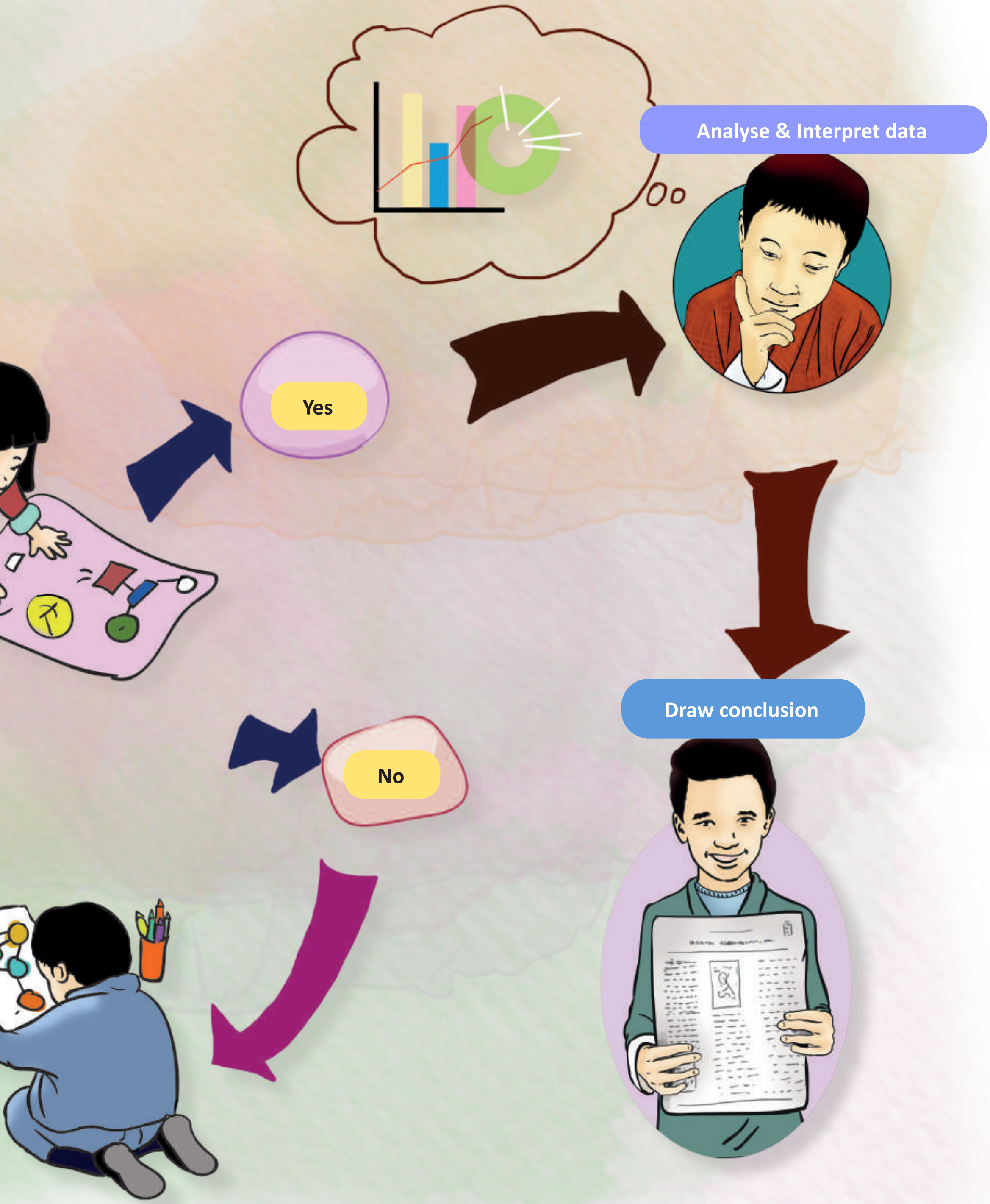
While writing conclusions, summarise how your results from the analysis support or contradict your original hypothesis. The conclusion should:

- summarise your science project results in a few sentences and use this summary to support your conclusion. Include key facts from your background research to help explain your results as needed.
- state whether your results support or contradict your hypothesis. Remember that it is not important for the hypothesis to be correct. However, it is important to explain why you got the results.
- if appropriate, state the relationship between the independent and dependent variable.
- summarise and evaluate your experimental procedures, making comments about its success and effectiveness.
- identify and critique procedural mistakes that could have affected the data.
- suggest changes in the experimental procedure (or design) and/or possibilities for further study.

The results of experiments or research are published to the scientific community by journal articles, newspapers, and or books. In the school level, you will mainly publish your results in the form of a Lab Report.

SCIENTIFIC METHOD




Analyse & Interpret data
Yes
Draw conclusion
No

Safety comes first. It should not be compromised at any cost while carrying out group or individual field work and physical activities. In order to be safe, your research needs thorough planning and preparation right from the beginning. An adequate knowledge of the site to be visited, strict supervision and code of conduct by each individual ensures the success of activities as well avoids numerous hazards. For a site visit, especially near water bodies and garbage disposal sites, a special code of conduct is suggested for various situation and time.

In the case of activities near water bodies, the following must be done before, during and after the visit.

Preparation and Planning

Pre-visit:

Teachers should carefully inspect sites before taking a group and make sure:

- to obtain legal and easy access to the site.
- to choose a safe access to the site with no erosion of riverbanks.
- to carry out risk assessment of the site.
- to locate shallow part of the streams, if there is need to get into the water or avoid getting into it.
- to check that the stream water is not swift even if it is shallow, which is a threat.
- to check that water in the stream appears clean enough if there is the need to get into water or whether we should avoid getting into it.
- the site is really suitable for the purpose.
- to identify suitable time during which site can be visited.
- each individual is thoroughly aware of the purpose of the visit and the code of conduct.
- rescue techniques are familiar and carry a first aid kit and throw bags when near the rivers.
- to locate and put signage on the areas of danger associated with sinkholes, slippery surfaces, silt and treacherous areas when working within the stream.
- one is aware of contaminants in the water, often caused by floodwaters.
- whether specific training is required before any tasks are undertaken on or near the water.

- to check all equipment is functional and is suitable for use.
- to check if there is a way of seeking assistance if it is required in an emergency.
- adequate equipment is packed e.g. torches, first aid kit, emergency food supply, maps, whistles, survival bags, etc., and students have the knowledge and ability to use the equipment.

During visit:

During the site visit, extra care must be taken. Make sure adequate supervision and self-discipline is maintained during the visit. Teachers should ensure that students:

- have the required clothing and footwear.
- wear rubber gloves and safety goggles while collecting samples and using chemicals.
- are aware of any potential hazards (physical hazards of the environment e.g. hypothermia, nitrogen narcosis, sunburn, etc., chemical hazards, infection from pathogenic organisms, dangerous animals and plants, food poisoning, basic personal hygiene, use of repellents, etc.)
- stay in visual contact with you all the time.
- nobody gets into the water unless asked to do so and no one splashes or pushes.
- cover any scratches or cuts with waterproof plasters.
- protect themselves from direct contact with the water and splashes into eyes, nostrils and mouth.
- do not eat or drink while working beside study sites.
- wash their hands with soap and clean water as soon as work has finished, and before they eat.

Post visit:

If samples are brought to the laboratory, ensure that:

- samples are properly labelled.
- samples are carefully transported to laboratory.
- all the laboratory rules are strictly followed during testing and analysis.
- dispose the samples and chemicals properly.

STUDENTS CODE OF CONDUCT

I agree to:

- obey all instructions given by my teacher/instructor.
- comply with the rules of that region or the sites.
- comply with health and safety arrangements for the work.
- behave in a required manner.
- notify teachers of allergies, sickness and if taking medication for an illness.
- respect the social and cultural beliefs of the community.
- ask permissions before I do certain things beyond the instruction.
- focus on the purpose of the visit and complete the task required.
- cooperate and collaborate with the group members.
- stay in the vicinity of teacher, not wander off on my own.
- not to push or shove my friends near the water or on the path.
- not to run near the water or swim in the water.
- wear appropriate attire and protective clothing for the visit.
- handle all the equipment, apparatus and chemicals carefully, at all time.
- treat all samples as if they are contaminated.
- treat all chemicals as if they are dangerous.
- wash hands thoroughly after using chemicals.
- not to put hands in mouth during experiments or taste a laboratory sample.
- not to shake, splash or spill the chemicals.
- dispose of chemicals properly.

Sample Projects
(Grade IV to VI)

SAFE WATER

Project 1: How safe is your drinking water?

Introduction

With increasing human activities, tourism operations and improper disposal of wastes in the community, many sources of water are contaminated. This has threatened the availability of a safe and clean drinking water supply for people as well as animals. There is a looming threat to the health of the people in the community due to the spread of waterborne diseases and the consumption of toxic water. The purpose of the project is to test the quality of drinking water.

Background

It is crucial to confirm that the water we consume is clean and safe. Water may be colourless, clear and odourless, but still may be contaminated and not safe to drink. One of the basic tests that can be performed to determine the quality of drinking water is to carry out pH test.

The pH test is useful to students and local residents to find out how acidic or basic their drinking water is. If the pH value of drinking water is too high or too low than the acceptable safe level, it is harmful to people and animals. Water with a very low or high pH is a sign of contamination and pollution. The pH value of water is a good indicator whether water is soft or hard. The pH of water varies across the world due to changes in weather patterns, human activities, and natural processes.

Method

The water samples are collected from different sources and at different times. The experiment is carried out as follows:

Aim: The purpose of the experiment is to check the pH level of drinking water.

Hypothesis: The pH value of drinking water is at a safe level.

Theory:

pH stands for "potential of hydrogen," referring to the amount of hydrogen found in a substance (in this case, water). pH is measured on a scale that runs from 0 to 14.

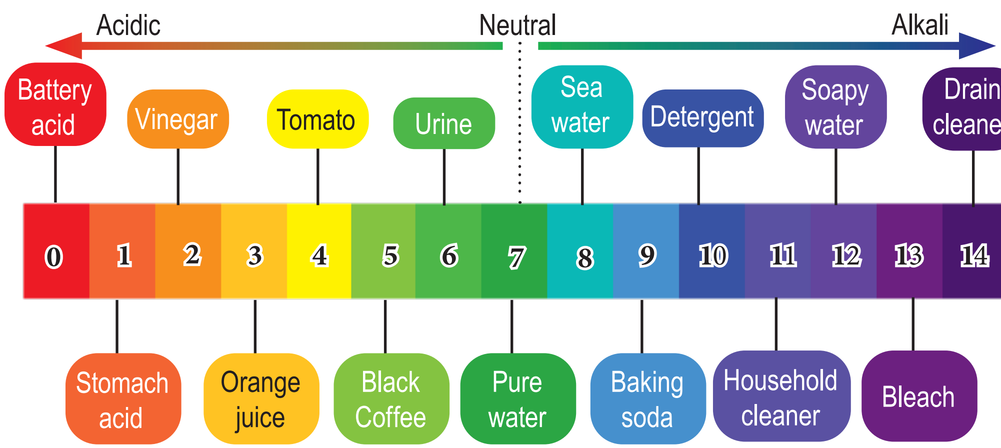


Figure 1.1.pH values of common substances

The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range of groundwater systems is between 6 to 8.5. In general, water with a pH less than 6.5 could be acidic and soft that damages the surfaces to which it comes in contact. Acidic water generally contains toxic metals such as iron, manganese, copper, lead, and zinc. Water with a pH greater than 8.5 could indicate that the water is hard. Hard water is not known to pose a health risk, but tastes bitter and can damage metal surfaces, moreover soap or detergent does not lather easily.

Material and apparatus required:

- Clean jars for collecting water samples
- 100 mL measuring cylinders
- 10 test strips for pH or pH indicator solution
- Universal indicator colour chart
- 4 test tubes
- Droppers
- Observation sheets
- Safety goggles and rubber gloves

Procedure:

I. Using Universal Indicator Solution

Step 1. Collect 100 mL of water samples in clean jars from different sources, such as:

- Water from tap
- Water from water filter
- Water from your water source
- Water from nearby stream

Step 2. Label each water sample as "Sample 1-Stream water", "Sample 2-Tap water" and so on.

Step 3. Take 10 mL of stream water in a test tube. Label it as "Sample 1- Stream water"

Step 4. Drop five drops of universal indicator solution into the test tube of stream water.

Step 5. Give a little shake to mix the solution thoroughly with water.

Step 6. Match the colour of solution in the test tube with universal indicator colour chart. If the colour appears to be in between two colour blocks on the chart, estimate the value of pH. Use Observation Table 1.1 to record the values.

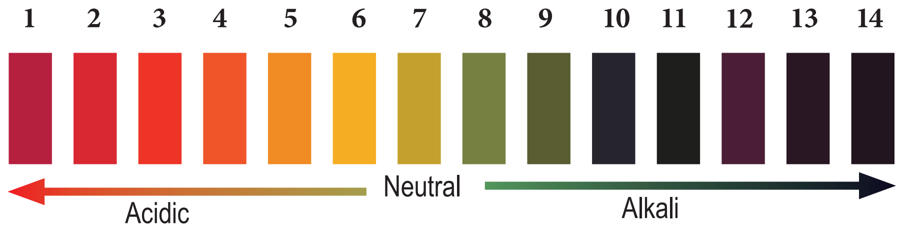


Figure 1.2. pH colour chart

Step 7. Test the pH value two more times for the same sample. Find the average value.

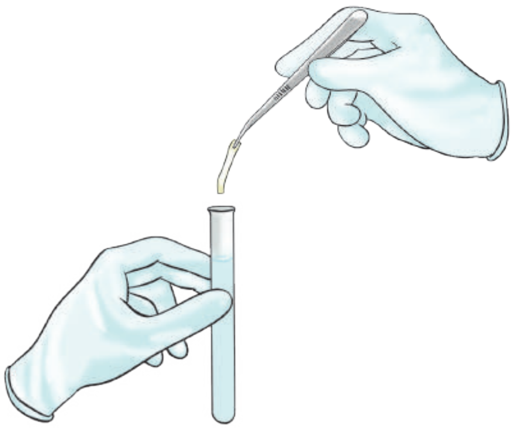
Step 8. Take another test tube and find the pH value of each water sample by following through Step 3 to Step 6.

Step 9. Clean the droppers, test tubes and other containers for future use.

II. Using Universal Indicator test strips

Step 1. Collect 100 mL of water samples in clean jars from different sources, such as:

- Water from tap
- Water from water filter
- Water from your water source
- Water from nearby stream



Step 2. Label each water sample as "Sample 1-Stream water", "Sample 2-Tap water" and so on.

Step 3. Take 10 mL of stream water in a test tube. Label it as "Sample 1-Stream water"

Step 4. Dip a universal indicator test strip into the water in the test tube and remove the strip immediately.

Step 5. Do not shake the excess water from the test strip. Hold the strip at a level for about 15 seconds.

Step 6. Match the colour of the test strip with universal indicator colour chart and read the value. If the colour appears to be in between two colour blocks on the chart, estimate the value of pH. Use Observation Table 1.1 to record the values.

Step 7. Test the pH value two more times for the same sample. Find the average value.

Step 8. Take another test tube and find the pH value of each water sample by following through Step 3 to Step 6.

Step 9. Clean the droppers, test tubes and other containers and apparatus for future use.

Observation

To confirm the pH value, each water sample must be tested three times. The pH of water can be tested at different seasons. The following table is used to record the readings and observations.

Observation Table 1.1 pH value of water samples

Sample No	Source	pH value			
		Test 1	Test 2	Test 3	Average
Sample 1	Stream Water				
Sample 2	Tap Water				
Sample 3					
Sample 4					

Result

1. The average pH value of Stream Water =………, which is……………… (highly/slightly)………… (acidic/basic)
2. The average pH value of Tap Water =………, which is……………… (highly/ slightly)………… (acidic/basic)
3. The average pH value of Tank Water =………, which is……………… (highly/slightly)………… (acidic/basic)
4. The average pH value of Filtered water =………, which is……………… (highly/slightly)………… (acidic/basic)

Conclusion:

1. The water from………… /and ……. contains toxic materials and therefore is not suitable for drinking.
2. The water from …………… /and ………. are (is) suitable for drinking.

Safety!

- Be careful on slippery surfaces, steep slopes, high and/or fast water when collecting the water samples.
- Water test kits must be carefully handled as it contains glass apparatus and some chemicals are hazardous.
- Dispose waste water from the tests in an appropriate way.

WATER POLLUTION

Project 2: How are water sources and streams in your locality polluted?

Introduction

With the rapid rise in human activities and waste production, nearly half of our rivers and streams, and more than one-third of our lakes are polluted. The water in these bodies is unfit for swimming, fishing, and drinking.

Dirt is a big cause of pollution in our rivers and streams that harm marine animals and plants. Most of the dirt washed by rain into streams come from exposed earth, such as ploughed fields, construction sites, and areas that have been logged or mined.

Presence of bacteria, virus and germs degrade the water quality. Even though not all bacteria are harmful, some bacteria, germs and viruses can make people and animals sick when consumed. Bacteria can come from sewers after rainstorms and runoff of animal waste from farms, pets, and wildlife.

The runoff of fertilisers from farms and lawns, animal waste, sewage treatment plants, and septic systems into streams can cause algae bloom turning it green, or contaminate it with harmful germs, bacteria and virus that can make human sick.

Polluted and contaminated water from streams and rivers flow into ponds, lakes, and the sea. Thus, keeping streams and rivers upstream clean can help keep all the water downstream clean.

Background

With increasing development and human activities in the community, waste production has increased and irresponsible disposal of wastes is affecting the environment and human health. Different types of wastes, mainly non-degradable wastes, are produced in huge amounts. Plastic bottles, plastic bags, food pack covers, clothes and rags are scattered all around in fields, streams, roads and homes. Farmers are increasingly using more chemical fertilisers and insecticides in their farms. Septic tank spill-over, animal waste and oil spill into streams are very common in the community. Thus, water borne diseases can be very common and frequent in the community living along the stream as the stream is a source of freshwater for the community.

Facts About Water Pollution

- Soap from washing your car can run down the street drain and cause water pollution.
- Between 5 and 10 million people die each year from water pollution related illnesses.

The main purpose of the study is to find out how the stream is polluted and the type of pollutants that are common in the community.

Method

Students visit the site along the stream. Students draw a map and indicate the pollution zone along the stream. Students also collect the type of pollutants and their quantity.

Aim: The purpose of the study is to identify the pollution zone and the type of solid wastes.

Hypothesis: The pollution is more in the areas of settlements.

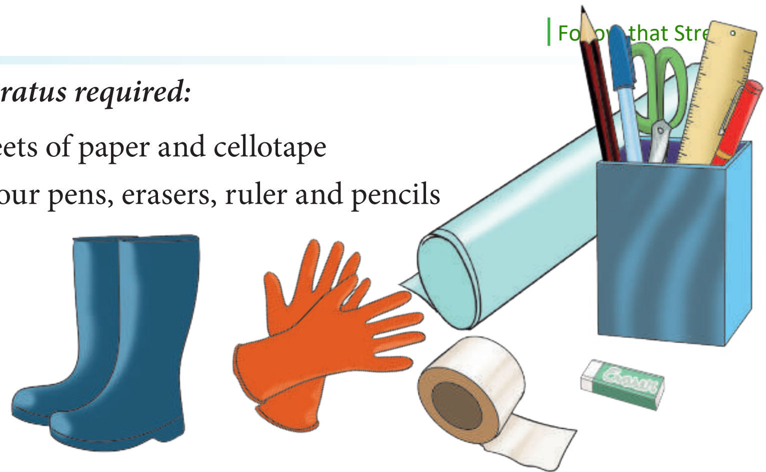
Theory:

Water pollution occurs when harmful substances from wastes contaminate a stream, river, lake, ocean, etc., degrading water quality and making it toxic to the humans or the environment.

Water is a universal solvent. Toxic substances and wastes from homes, farms, and factories readily dissolve in water, causing water pollution.

Material and apparatus required:

- Chart paper, sheets of paper and cellotape
- Marker pen, colour pens, erasers, ruler and pencils
- Plastic bags
- Gloves
- Water boots



Procedure:

Step 1. Select a small stream in your locality.

Step 2. Visit a region 50 m upstream where there is no settlement. Mark it as 'Spot 1'.

Step 3. Observe the wastes that are visible around and in the stream on Spot 1 (DO NOT touch the waste with bare hands. Use stick to handle the waste that is in the water)

Step 4. Use the observation Table 2.1 to record the observations.

Step 5. Walk down 50 m along the stream to Spot 2. Do the following:

i. Observe the flow of the stream and the settlements around. Draw the rough sketch of the area on a blank sheet of paper and mark the houses, sheds, wastes dump sites, toilets, etc.

ii. Observe and identify different types of wastes disposed and fill in Table 2.1 and mark the area in your map where more quantity is found.

Step 6. Walk down 50 m downstream to Spot 3 and again observe as in Step 5 (i) and (ii)

Step 7. Repeat Step 6. Make sure you have the following after the completion of this step.

i. A rough map of the stream and the region around it.

ii. The type and quantity of wastes found along the stream bank.

Step 8. Draw the final map using colour pencil and marker on the chart paper. Please indicate the components using legends and shade the area that is a pollution zone.

Observation

Observe both the sides of the stream and record your findings.

Observation Sheet

Name of the stream:

Village:

Date of Observation:

Spot	Place	Population	Wastes (tick one that apply)						
			Plastic bags	Bottles	Food wrappers and packets	Paper	Cans and tins	Clothes and rags	Food wastes
Spot 1	50 m above the settlement	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐
		Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐
		More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐
Spot 2	50m below Spot 1	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐
		Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐
		More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐
Spot 3	50 m below Spot 2	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐
		Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐
		More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐
Spot 4	50 m below Spot 3	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐	None ☐
		Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐	Less ☐
		More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐	More ☐

Result

You may draw a similar map as shown below in Figure 2.1.

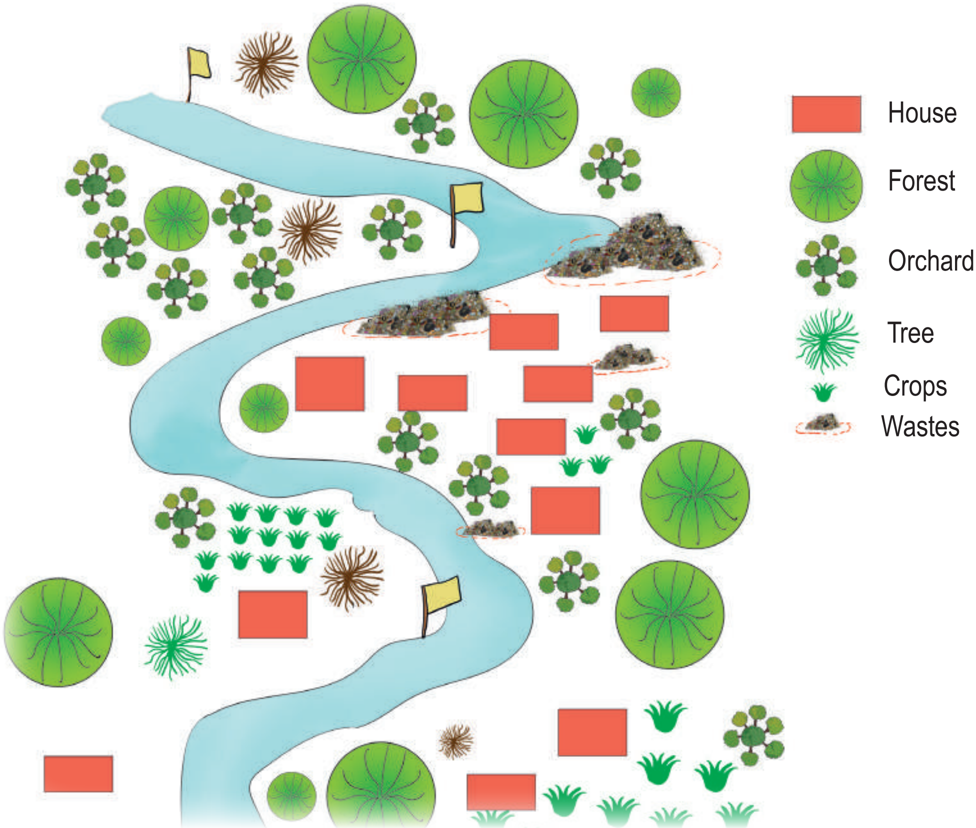


Figure 2.1. Site map

It was found that:

1. The type of waste disposed along and into the stream was mainly.........................

2. The level of pollution of the stream is.................... (high/ low/none)

Conclusion

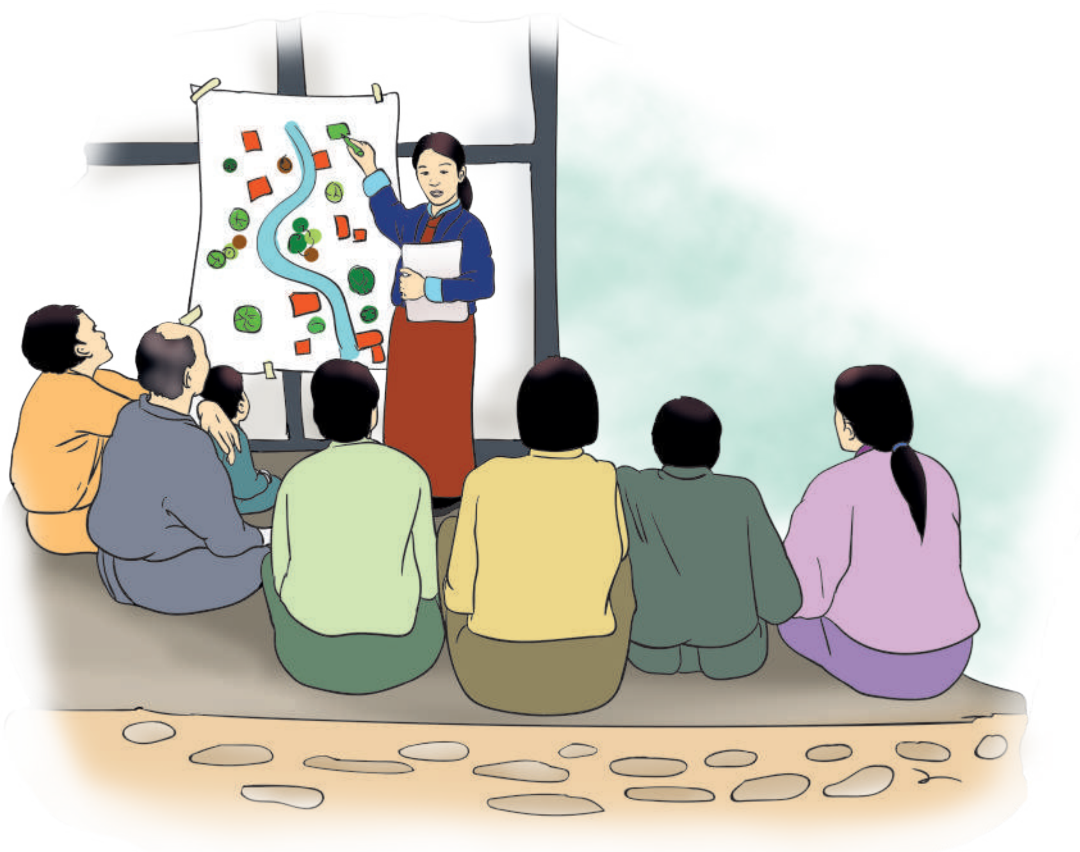
The region of the stream that is polluted most is in the area where the settlement is………… . This is mainly due to…………………………………

Presentation

Mount your map on the wall and present your findings to your class.

Present your findings to the people in your community and explain them the following:

- why our streams are polluted
- why our streams need to be protected and what should be done.



Safety!

For the teacher...

- Make sure the stream site is safe for students.
- Check for walking conditions, litter, potentially dangerous wastes, wildlife, and poisonous plants.
- Bring a first aid kit on the trip.
- Define the boundaries of your visit. Make sure students understand that staying within these boundaries will keep them safe and protect wildlife.
- Locate a place where students can wash hands after the visit.

For the students...

- Stay with group members at all times.
- Wear waterproof boots because they will likely get wet and muddy. Keep shoes on at all times to protect feet from harm.
- Stay in the designated area, and do not go near or into the water except to collect water samples.
- Do not touch any wildlife that you find or taste any water or plants.
- Be careful on slippery surfaces, steep slopes, high and/or fast water when collecting the water samples
- Do not touch wastes with bare hands.
- Do not eat any food without first carefully washing your hands.

SHRINKING WATER SOURCES

Project 3: How to Save Water?

Introduction

About 70 percent of the Earth's surface is covered with water. It is in the form of oceans, lakes, rivers and streams. Oceans comprises of about 97 percent of all surface water. Therefore, only 3 percent of all the Earth's water is freshwater. Out of which, about 69 percent of freshwater is unusable by humans since it is frozen in the form of glaciers and ice caps. Ultimately, of all the freshwater on the Earth, only about 0.3 percent is found in lakes, rivers and streams that can be used by human in their everyday lives.

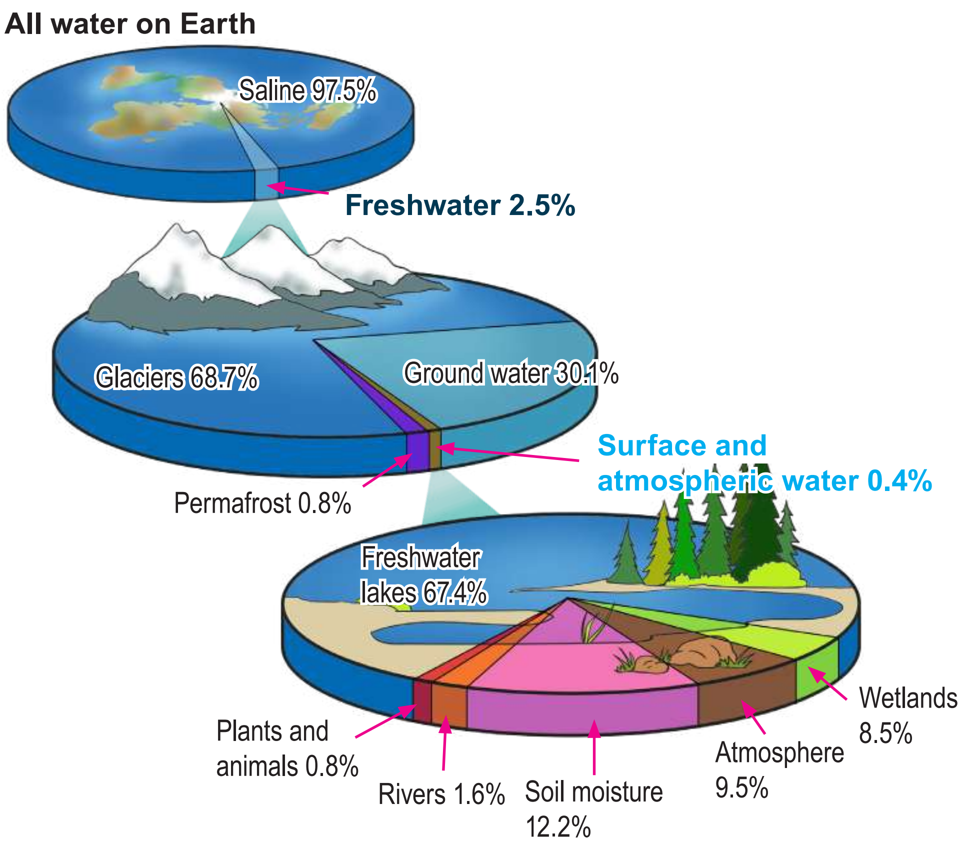


Figure 3.1. Water on Earth (Source;UNESCO)

Water plays a central role in the everyday lives of the Bhutanese people. In most parts of the country, the water for household use is obtained from ponds, streams and springs. Water for drinking and livestock are often carried on human backs over long distances. One of the most widespread uses of water is for farming. Generally, farmers depend on seasonal rainfall. Other times, the water for irrigation is drawn from small streams and springs. Unlike other countries, groundwater is rarely extracted for irrigation purposes in Bhutan. In villages, grains, such as corn, wheat, barley and buckwheat are processed using water mills.

Background

There are plenty of freshwater sources in Bhutan for daily use, but the cost of delivering water services is very high. The rise in population in some communities is increasing the demand for water. The unpredictable climate, rainfall and temperature rise further pose challenges in getting enough water for household use and farming. In addition, we waste lots of water through leaks due to defective pipe joints, cracked and broken pipes, faulty valves and fittings. We hardly recycle waste water. Therefore, conservation of water is urgent. Saving water starts at home. We need to know how much of water is used by each person daily and how much of water is being wasted. Learning water saving techniques and practising them will ensure enough water in the community which will save energy, time and money.

Method

This personal survey is carried out to find out how much water each person uses in a day and compare with the normal consumption rate. The comparison will point out whether water is over-consumed or wasted. Observations are also made in and around the house to find out other ways by which water is being wasted. The water saving techniques are identified and practised, and the average saving cost is calculated.

Aim: The purpose of the study is to find out the various purposes of water and the ways to conserve it.

Hypothesis: Water use habit and water saving techniques are directly related to decrease in water consumption.

Theory:

Water is a necessity for all organisms. Determining how much water is needed is the first step in finding out water wastage. The water needs to be collected, stored, treated and water supply maintained. These require cost labour, time, resources and money. Consuming too much water is a waste of money and also may deprive people elsewhere of water, and have adverse environmental and health impacts.

People use water for a wide variety of activities, such as drinking, washing, bathing, farming, etc. The requirement of each person mainly depends upon the habits, social status, climatic conditions and customs of the people. Some of these activities are more important than others. For example, having a few litres of water to drink a day is more essential than washing clothes. However, to stay healthy, people need to keep themselves clean. Under normal conditions, the amount of water required as per the urgency of the activity is shown below in Figure 3.2.

Figure 3.2. Hierarchy of water requirements

In Bhutan, the demand for water peaks during dry months. Daily variation of water use also depends on the activities. People use more water on Sundays and festival days.

Material required:

- Notebook
- Pencil or pen
- Survey forms
- Observation sheets

Did You Know?

Water leaks

60 drops per minute = 800 L per month

90 drops per minute = 1170 L per month

120 drops per minute = 1620 L per month

Procedure:

Step 1. Carry out home water use survey and complete Home Water Use Audit (Normal Use) Form to calculate the cost of your daily water usage as well as the usage of your family members.

Step 2. Locate the water leaks in toilet, bathroom, kitchen and outdoors and calculate the cost.

Step 3. Change your habits and that of your family members, by adopting water conservation methods as given in TIPS to Conserve Water poster.

Step 4. Carry out home water use survey again using Home Water Use Audit (Conservation) and calculate water use cost.

Step 5. Find out the total amount of water and cost saved.

Observation

Follow the instruction given on each form carefully.

Home Water Use Audit Form (Normal Use)

Instruction: Calculate your daily water usage as well as the usage of your family members. Record how many times/day you carry out each activity. Multiply the amount by the quantity of water you use with the number of family members to find out the total amount of water used. Use the rate of water use given to calculate the total cost for water use in a day.

Name:. ....

Number of family members : ....

Village: ....

Gewog:...........................

Number of families in your village/town :..................

Activity	Number of times/ day	Normal Water Usage Description	Amount of Water Used	Total (you)	Total (family) = Total (you) x no. of family members
Flushing Toilet		Push button flush toilet	14 L		
Taking a Shower		Using a regular shower-head, having a long shower	100 L		
Taking a Bath		Leaving the tap on while bathing	100 L		
Brushing Teeth		Leaving the tap on while brushing	14 L		
Hand washing		Leaving the tap on while hand washing	5 L		
				TOTAL 1 (Individual Use)	

Activity	Number of times/day	Normal Water Usage Description	Amount of Water Used	Total
Cooking		Water for cooking, washing vegetable and food on running water	50 L	
Hand washing Dishes		Leaving the tap on while washing	110 L	
Washing clothes		Washing machine	215 L	
Car washing		Leaving the tap running	400 L	
Watering the flower garden		Watering the lawn in the middle of the day	180 L	
			TOTAL 2 (Family Use)	

Grand Total of water use / day = TOTAL 1 (Individual Use) + TOTAL 2 (Family Use) =……..…. L

Estimated amount of water required home use by your village in a day =……………………… L

1 Cubic Metre = 1000 L
Cost of 1 Cubic Metre of water = Nu 3.58 (Thimphu City)

Divide your Total Normal Water Usage by 1000 L to calculate the water usage in cubic metre.

Multiply that number by the cost per cubic metre.

Cost of water use for your family per day = Nu…………………………

Cost of water use for all the families in your village per day = Nu…………………………

Home Water Use Audit Form (Conservation)

Instruction: Read the tips on the poster and practice a few things at home and then calculate your daily water usage as well as the usage of your family members. Record how many times/day you carry out each activity. Multiply the amount by the quantity of water you use with the number of family members to find out the total amount of water used.

Use the rate of water use given to calculate the total cost for water use in a day.

Name: ....

Number of family members : ....

Village: ....

Gewog: ....

Number of families in your village/town: ....

Activity	Number of times/ day	Water Usage Description after conservation	Amount of Water Used	Total (you)	Total (family) = Total (you) x no. of family members
Flushing Toilet		Using pour flush	5 L		
Taking a Shower		Having a short shower	50 L		
Taking a Bath		Bucket bath	50 L		
Brushing Teeth		Closing the tap on while not in use	1 L		
Hand washing		Closing the tap on while not in use	2 L		
				TOTAL 1 (Individual Use)	

Activity	Number of times/ day	Water Usage Description after conservation	Amount of Water Used	Total
Cooking		Cooking in water and washing vegetable and food using bowl of water	30 L	
Hand washing Dishes		Closing the tap on while not in use	110 L	
Washing clothes		Washing in buckets	100 L	
Car Washing		Closing the tap on while not in use, using less soap	400 L	
Watering the flower garden		Water in the cooler hours, early morning or late evening	100 L	
			TOTAL 2 (Family Use)	

Grand Total of water use / day = TOTAL 1 (Individual Use) + TOTAL 2 (Family Use)

=................ L

Estimated amount of water required for home use by your village in a day =.................. L

Divide your Total Normal Water Usage by 1000 L to calculate the water usage in cubic metres. Multiply that number by the cost per cubic metre.

1 Cubic Metre = 1000 L
Cost of 1 Cubic Metre of water = Nu 3.58 (Thimphu City)

Cost of water use for your family per day = Nu.............................

Cost of water use for all the families in your village per day = Nu.............................

Result

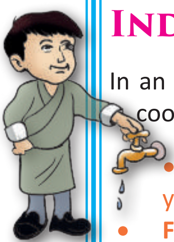
1. The amount of water used in normal conditions in my household =........... L
2. The amount of water used after adopting water conservation methods is =...... L
3. The total amount of water saved is =................... L, which is = Nu ....
4. The amount of water used in normal conditions by whole village =............. L
5. The amount of water used after adopting water conservation methods by whole village is =.................. L
6. The total amount of water saved by whole village is =... L, which is = Nu ...

Conclusion

1. The amount of water consumed can be reduced by:
   a. .... and
   b. ....
3. Saving water will
   a. .... (increase/decrease) the cost.
   b. ....(increase/decrease) water scarcity.
   c. .... (increase/decrease) labour and energy.

TIPS TO CONSERVE WATER

INDOOR



In an average home, two-third of water is used in the kitchen and bathroom, mostly for cooking, flushing toilets, showering, and bathing.

- **Turn off the water when you are not using it.** Don't let it run while you brush your teeth, wash face and hands, bath, wash food and vegetables, etc.
- **Flush the toilet less often and use pour flush toilet**. Dispose used tissues, trash, hair, paper towels, etc. in the waste basket instead of flushing them. Collect grey water (used water from washing clothes, cars, bath) to flush toilets
- **Fix leaks and drips**. Repair leak and drips often.
- **Take shorter showers**. Less than 5 minutes is adequate; any longer is recreation.
- **Take bucket baths**. Bucket bath uses less water than a shower.
- **Use appliances efficiently.** Run full loads in the dish or clothes washer and buy water efficient devices that are designed to minimise water use.
- **Clean vegetables and fruit efficiently**. Soak vegetables and fruits in bowl of water to remove deep dirt and muds. Brushing them will make washing faster.
- **Drink water from bottle or cup**. Avoid drinking from running tap.

OUTDOOR

Watering garden, washing walkways and vehicles consume lots of water and water wastage can be avoided.

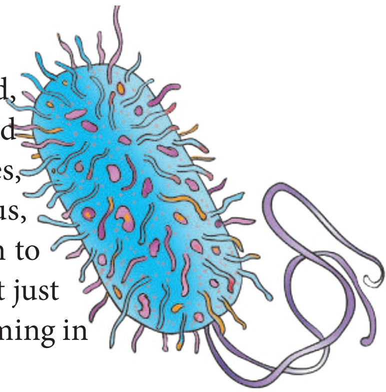
- **Water the lawn and garden only when necessary**. Early morning or evening are the best times. Mulch your trees and plants. Do not water the garden after adequate rainfall.
- **Use water cans to water garden**. Water through hosepipe consumes as much as 1000 L per hour.
- **Avoid watering driveways and sidewalks**. Sweep dry leaves and dust using broom.
- **Plant right type of flowers and plants**. Select and plant beautiful flowers and plants which thrive with less watering.
- **Wash your car sensibly**. Clean the car with a bucket of soapy water and use the water only for a quick rinse. Avoid washing car daily.
- **Placing a cover over your water tank. Covering water in buckets and tanks** reduces water loss due to evaporation.
- **Reuse water.** Collect water used for cleaning vegetables and fruits to water your garden.
- **Install a water meter**. Knowing exactly how much water you use will control and reduce water wastage.

Sample Projects
(Grade VII and VIII)

WATER BORNE DISEASES

Project 4: Which diseases are caused by pollution of water?

Introduction



Water is the source of life. It is essential for people to grow food, drink and clean. However, freshwater of the world has been polluted by waste, chemicals and litter from our homes, farms, industries, etc. Polluted water contains several pathogens (especially virus, bacterium or other microorganism) that can cause serious harm to the human body. Therefore, diseases can easily be contracted not just by drinking contaminated drinking water, but also by simply coming in contact with it.

According to World Health Organisation more than 3.4 million people die from water borne diseases every year, making it the leading cause of disease and death in the world (Berman, 2009). Our country spends a good amount of resources and money in treating the water borne diseases, which would otherwise be prevented.

Background

We use water from various sources that appears clean for all household activities like cleaning, cooking, washing, bathing, drinking, etc. The water may be contaminated and carry pathogens. Our fields are also irrigated with water from streams and ponds. The chemicals dissolved in it may be transferred and contaminate the food we grow. Is the water we use safe?

There are several measures taken to clean water to use it. However, first, it is important to know the types of common diseases caused by contaminated water, the sanitary conditions in the locality, and also the habits and awareness among the locals. This information is very useful in taking appropriate actions on the spread of water borne diseases.

Method

This survey on health and diseases is carried out in the community and the school. The information on common diseases and the sanitary practices is collected from villagers and the students. The records of students' health from school and villagers' health record are also studied. Observations are also made in the surroundings to identify the possible breeding ground for disease spreading organisms.

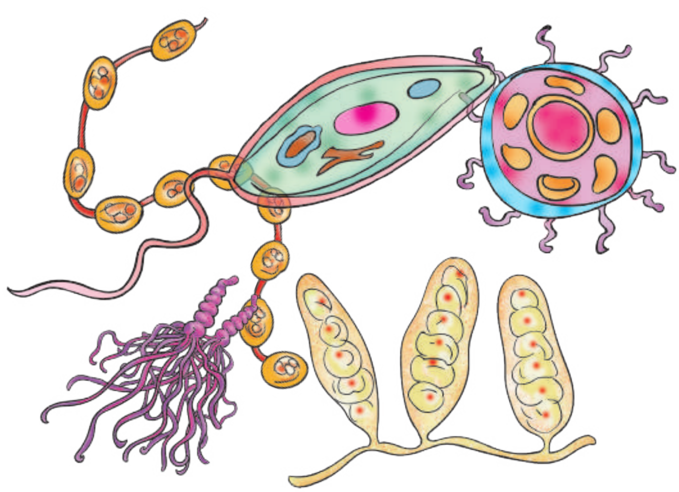
Aim: The purpose of the study is to determine the common types of water borne diseases in the community.

Hypothesis: The water borne diseases are mostly due to drinking and using contaminated water.

Theory:

Water borne infections can be divided into four groups, according to how they transmit:

1. Diseases spread by drinking contaminated water.
2. Diseases spread due to lack of hygiene and sanitary facilities.
3. Diseases spread through direct contact with contaminated water (like swimming) or indirect contact (eating fish that carry infection from contaminated water).
4. Diseases like malaria spread through bites of insects (mosquitoes) that need water to breed.



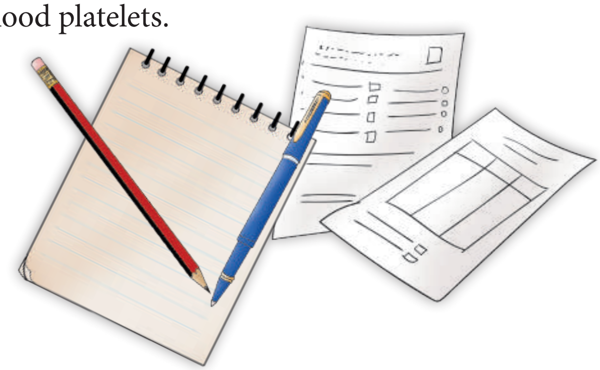
Some of the diseases, their symptoms and the causes are given below in the chart.

Disease	Symptom	How it spreads	Caused by
Diarrhoea	Loose, watery stools, gas, abdominal cramps and pain, fever and sometimes blood in the stool, dehydration	Disease usually spreads through contaminated food and water that enters the human body and poor hygiene.	Virus – *norovirus or rotovirus* Bacteria- *campylobacter, clostridium difficile Escherichai coli*
Typhoid	High fever, sweating and shivering, headache, stomach pain and weakness. Some people with typhoid fever develop a rash called "rose spots "on the abdomen and chest.	Disease spread through food and drinking water contaminated by stools carrying the bacteria.	Bacteria -*Salmonella Typhi*
Dysentery	Frequent passage of stools with blood and/or mucus, and loss of appetite. In some cases, vomiting and fever	Spread by hand-to-mouth transfer from person-to-person or through water and food that have been contaminated by an infected person or flies. Poor hygiene and eating raw vegetables or fruit grown in contaminated soil.	Bacteria -*Shigella* Protozoan- *Entamoeba histolytica*
Cholera	Severe watery diarrhoea and vomiting that leads to dehydration and even death if untreated, leg cramps, dizziness and rapid weight loss	Eating food or drinking water contaminated by stools from an infected person. Vegetables grown with water containing human wastes, raw or undercooked fish and seafood caught in waters polluted with sewage.	Bacteria -*Vibrio Cholerae*
Malaria	Fever, shivering, sweating, headache, vomiting, abdominal pain, diarrhoea, muscle pain	Spreads to people through mosquito bites. Mosquitoes thrive in water in drains clogged up by waste and stagnant water.	*Plasmodium* parasite – *plasmodium falciparum, plasmodium vivax, plasmodium ovale, plasmodium malariae, plasmodium knowlesi*
Hepatitis A	Fatigue, fever, abdominal pain, nausea, diarrhoea, weight loss, itching and jaundice	Lack of safe water, and poor sanitation and hygiene. Eating contaminated fruits, vegetables, or other foods Eating raw shellfish harvested from contaminated water.	Hepatitis A Virus (HAV)
Polio	Headache, fever, and seizures, vomiting, stiffness of the neck and pain in the limb paralysis (usually in the legs)	Mainly spread by hand-to-mouth transfer from person-to-person or through water and food that have been contaminated by an infected person or flies.	Virus- *Poliovirus*
Leptospirosis	High fever, severe headache, muscle pain, shivering, redness of the eyes, abdominal pain, jaundice, vomiting, diarrhoea, and rash.	Infected through direct contact with the urine of infected animals or with a urine-contaminated water and food.	Bacteria- *Leptospira*

Escherichia coli (E. coli) is a type of bacteria, transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products, raw milk, and contaminated raw vegetables and sprouts, contaminated drinking-water and from recreational waters. Consuming water contaminated with E.coli causes abdominal cramps, life-threatening diseases causing acute renal failure and low blood platelets.

Material required:

- Notebook
- Pencil or pen
- Interview sheets
- Observation sheets



Procedure:

Step 1. Before a survey, introduce yourself and the purpose of the survey, i.e., to find out hygiene, water, and sanitation issues leading to spread of diseases. Your respondents must know that there are no wrong or right answers and their answers remain confidential. Carry out the personal interview survey using the survey sheet (Disease Interview Guide- Students) on 10 students (randomly selected) from your school on the occurrence of water borne diseases.

Step 2. Similarly, interview 3 random people from the locality using survey sheet- Disease Interview Guide–Villagers).

Step 3. Observe the surroundings of their house and complete Data Sheet 1 (Home surroundings).

Step 4. Plot a graph showing the 5 common water borne diseases in your locality.

Step 5. Seek an appointment with the health official.

Step 6. Check the health records of people for the past 3 months in the nearby Basic Health Unit or health centre.

Step 7. Complete Data Sheet 2 (Health Records) and interview the health official on the causes, prevention and treatment of water borne diseases using Cause and Prevention Interview Guide (Health Official).

Step 8. Make a poster on any one of the water borne diseases showing the causes and its prevention.

Step 9. Organise an exhibition and display it to students and the local people of the community.

Observation

To find the spread of waterborne diseases, the following personal interview survey guidelines are to be used:

Disease Interview Guide (Students)

Class: ....
Age: ....
Gender: ....

Questions for interviewee	Interviewer Instructions
Thank you for joining this discussion. We want to find out your opinions about hygiene, water and sanitation issues leading to spread of diseases. There are no wrong or right answers; we just want to know your opinion. You can say what you want, and what you say will not be quoted individually.	Introduction (To explain objectives and establish ground rules)
1. Where do you get drinking water from at school? 2. (If the answer is" from a water tank"): Is water always available? 3. Do you like the water? Why? 4. How do you get water from the tank? 5. Do you think your water source at home is clean?	Key question focus is on accessibility of water PROBE: Clean and Convenient? (Ask only if the respondent does not mention these) PROBE: Use tap, dig with the help of Jerry can/jug or directly use their hands? PROBE: Dirty/ insufficient/ irregular supply
6. How do you keep your hands/body/ teeth/hair/ clothes clean? 7. When do you wash your hands? Why? 8. Why is it good to be clean? 9. What do you think of the cleanliness of toilet at school? 10. What do you think of the toilet at home? 11. Do you ever urinate/defecate outside the toilet?	Key question focus is on hygienic practices PROBE: Do you wash your hands after you use the toilet? Do you use soap? PROBE: Health/Smell/Status in family/community PROBE: Where? Why? Clean/Convenient Dirty/ Smells/No privacy/Too far

12. What illnesses are common in your friends? 13. What illnesses are common amongst your family members? 14. How often you get these illnesses or fall sick? 15. How do you/they get these diseases?	Key question focus is on diseases PROBE: Diarrhoea/ Colds/ Malaria/ Typhoid/ Fever, vomiting, dysentery, malaria, etc. (Note all) PROBE: Weekly, biweekly, monthly, quarterly, yearly PROBE: Dirty water/Dirty hands/Other people coughing/Flies/mosquitoes/Dirty fruit/Dirty dishes or table/ smelly garbage and litters/ animal wastes, swimming/ unhygienic food
16. How do you prevent these diseases? 17. Where do you learn about hygiene? 18. What activities related to hygiene do you learn in school?	Key question focus is on knowledge and awareness level PROBE: Hand washing/Boiling water/ Cleaning the house/ Washing fruits and vegetables with clean water/ water treatment/ bathing regularly PROBE: Home/ School/ Medical facility/ Your friends/ Media (internet, newspapers, campaigns)
19. What are your recommendations to improve the water, sanitation, and hygiene situation in your school and at home?	

Disease Interview Guide (Villager)

Age: ....

Gender: ....

Occupation: ....

Questions for interviewee	Interviewer Instructions
Thank you for joining this discussion. We want to find out your opinions about hygiene, water, and sanitation issues leading to spread of diseases. There are no wrong or right answers; we just want to know your opinion. You can say what you want, and what you say will not be quoted individually.	Introduction (To explain objectives and establish ground rules)
1. Where do you get water for drinking and other use at home? 2. (If the answer is" from a water tank"): Is water always available? 3. Do you like the water? Why? 4. How do you get water from the tank? 5. Do you think your water source at home is clean?	Key question focus is on accessibility of water PROBE: Clean and Convenient? (Ask only if the respondent does not mention these) PROBE: Use tap, dig with the help of Jerry can/jug or directly use their hands? PROBE: Dirty/ insufficient/ irregular supply

6. How do you keep your hands/body/ teeth/hair/ clothes clean? 7. When do you wash your hands? Why? 8. Why is it good to be clean? 9. What do you think of the cleanliness of toilet at home? 10. Do you have public toilet in your community? 11. Do you ever urinate/defecate outside the toilet?	Key question focus is on hygienic practices PROBE: Do you wash your hands after you use the toilet? Do you use soap? PROBE: Health/Smell/Status in family/community PROBE: Where? Why? Clean/Convenient Dirty/ Smells/No privacy/Too far
12. What illnesses are common amongst your family members? 13. How often you get these illnesses or fall sick? 14. How do you/they get these diseases? 15. What illnesses are common in your locality?	Key question focus is on diseases PROBE: Diarrhoea/ Colds/ Malaria/ Typhoid/ Fever, vomiting, dysentery, malaria, etc. (Note all) PROBE: Weekly, biweekly, monthly, quarterly, yearly PROBE: Dirty water/Dirty hands/Other people coughing/Flies/mosquitoes/Dirty fruit/Dirty dishes or table/ smelly garbage and litters/ animal wastes, swimming/ unhygienic food
16. How do you prevent these diseases? 17. Where do you learn about hygiene from?	Key question focus is on knowledge and awareness level PROBE: Handwashing/Boiling water/ Cleaning the house/ Washing fruits and vegetables with clean water/ water treatment/ bathing regularly PROBE: Home/ School/ Medical facility/ Your friends/ Media (internet, newspapers, campaigns)
18. What are your recommendations to improve the water, sanitation, and hygiene situation in your locality?	

Cause and Prevention Interview Guide (Health Official)

Sl No.	Diseases (Common in the locality)	Causes	Prevention	Treatment

Data Sheet 1 (Home surroundings)

Please observe carefully and tick the appropriate response.

A. Water and Drainage	(√ / X)
1. Is the source of water for general use and for drinking common?	
2. Are drinking water containers properly covered?	
3. Are water containers clean?	
4. Are there drains around the house?	
5. Is there any stagnant water pool visible that may breed mosquitoes?	
6. Does waste water go into streams?	
B. Garbage and waste disposal	
1. Are there animal faeces visible in the yard?	
2. Do you see litters around the house?	
3. Is there a proper disposal pit?	
4. Is it near the stream?	

C. Sanitary conditions

1. Does the house have toilets? ☐ Yes ☐ No
2. What is the type of toilet?
   ☐ Pit ☐ flush ☐ pour flush ☐ septic tank ☐ drains into streams
3. Where is it located?
   ☐ Inside the house ☐ far away from house ☐ next to stream
4. What is the condition of toilet?
   ☐ Clean ☐ clean but smelly ☐ dirty and smelly
5. What is the distance from the toilet to the water source?
   ☐ Water is inside the toilet ☐ just outside the toilet ☐ far away or no water

Data Sheet 2 (Health Records)

Browse the records and complete the table given below:

Month	Gender	Student/ Villager	Number of cases					
			Diarrhoea	Dysentery	Typhoid	Cholera	Malaria	……..
Month 1 ……….								
Month 2 ……….								
Month 3 ……….								

Result

1. ……………………. % of students have knowledge and are aware of water borne diseases, and ……………… % of villagers do have knowledge and are aware of water borne diseases.
2. ……………………. % of students and ……………… % of villagers think that they have access to clean water.
3. ……………………. % of students and ……………… % of villagers practise good hygiene.
4. Out of five homes, ………. homes have continual clean water supply, ………………… homes have toilets, and ………….. homes have a proper drainage system.
5. There are ……………. (no/many) water pools for mosquitoes to breed, ………….. (proper/improper) garbage disposals and septic tanks are ……….. (open/covered)

Conclusion

1. The common water borne diseases are……………………………..
2. In my community, water borne diseases are mainly caused by the following:
   a. ……………………………
   b. ……………………………
   c. ……………………………
3. The following must be done to reduce the spread of water borne diseases:
   a. ……………………………
   b. ……………………………
   c. …………………………….

Safety!

- Be careful of slippery roads, dogs and other accident prone conditions while visiting houses in villages.
- Do not drink water from any source. It is wise to carry your own drinking water.
- Do not touch objects in the surrounding while making observations.

Increasing wastes

Project 5: How is the type of wastes generated a threat to your locality?

Introduction

Urbanisation has led to increasing waste challenges. This is a global trend especially in developing countries and least developed countries. In cities like Thimphu, the waste production has surpassed the capacity to manage it. As per the report by RSPN, it is found that accessibility to market and external products, garbage and water generation have increasingly become a cause of concern as well in rural areas in Bhutan. In a relatively short period of time, rural communities were introduced to manufactured goods which villagers find convenient and replaceable, but along with which comes some new waste materials to handle. Villagers now devote little time to develop effective, organic, sustainable, and culturally appropriate means of producing and using the products. The popular practice adopted by villagers to handle waste is by burning their garbage in household garbage pits. Further, increasing use of electrical appliances, such as rice cookers, light bulbs, grinders, and imported shoes and clothes, present other disposal problems for rural villagers. Household garbage, littering, and non-biodegradable waste are growing considerably in all rural parts of Bhutan. The Government efforts to tackle the waste problems face several challenges. It includes educating villagers to identify waste that could cause pollution in the modern sense, disposal of waste, inculcate modern household waste management practices to rural villagers and making citizens take personal responsibility for their waste.

Globally, more than half of the garbage is buried and stored in landfills. Many countries are promoting recycling programs, often getting schools involved so students can learn about recycling and follow these practices at home. Today, with recycling, composting, and reusing, we are able to greatly reduce the amount of garbage we produce.

Background

Solid waste management has become a practical necessity in rural areas of Bhutan. The domestic waste generated in rural households of Bhutan is generally organic and biodegradable. However, due to influx of manufactured good, the hazardous and non-biodegradable waste is increasingly becoming an issue of serious concern. A socially acceptable and technically sound waste management system must be placed in rural Bhutan for a healthy rural environment and quality living. The landfills for cities are often located in rural areas, which aggravates the pollution and contamination of environment. Garbage generally ends up in the river banks, streams, public places, street corners, etc.

Therefore, it is assumed that rural populations in Bhutan lack knowledge of waste segregation and disposal methods. Moreover, the rural community rarely has functional solid waste management systems in place. This project intends to find out the awareness and current practices of waste management in the community, helping them design and propose a solid waste management system.

Method

The solid waste management system in the locality is evaluated and improved by identifying waste generation, segregation and disposal practices.

Aim: The purpose of the study is to design the solid waste management plan for my locality.

Hypothesis: The solid waste management system is very poor.

Theory:

Garbage is complex. Even when an effort is made to sort their waste into glass, paper, recyclable plastic, and food, many items are hard to classify that contain a mixture of materials, such as electronic waste. The simplest way to classify and segregate waste is by determining whether the waste decomposes or decays, thereby, into biodegradable waste or non-biodegradable waste. It is also important to understand that the waste can be hazardous in nature. Figure 5.1 shows a chart of a simple waste management model.

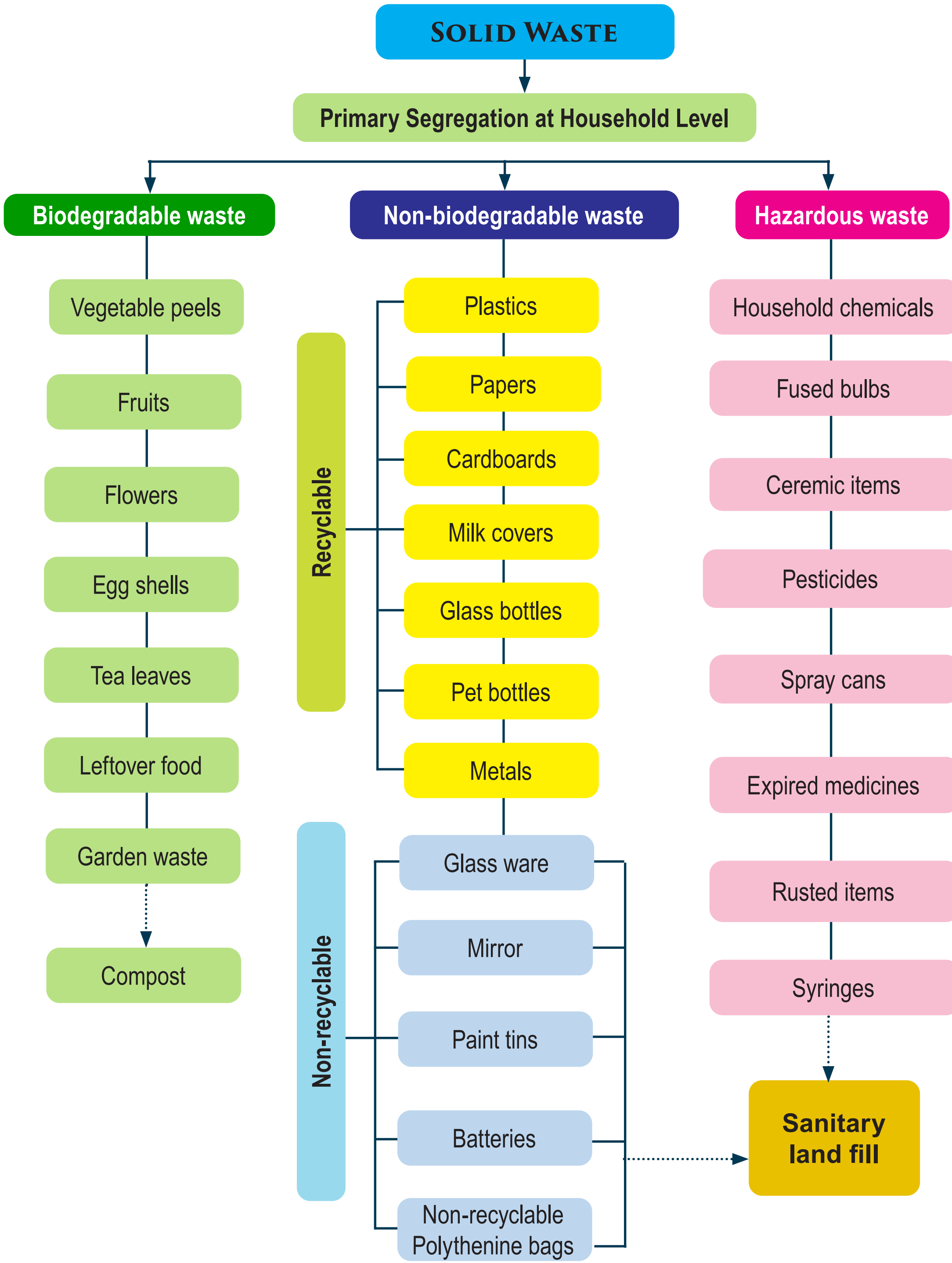


Figure 5.1. Simple waste management model

The primary segregation household waste commonly involves maintaining three bins: wet waste (kitchen waste - GREEN) and dry waste (BLUE), and hazardous waste (RED).

Wet Waste (GREEN): For vegetable peels, fruits, flowers, egg shells, tea leaves, including leftover food, old bread, fish bones, leaves, garden shrubs, and others easily degradable items.

Dry Waste (BLUE): For plastics, papers, card boards, shampoo bottles, empty cans/ tins / toothpaste tube / worn out toothbrush / milk covers, oil covers, glass bottles, pet bottles, broken toys, caps of mineral water bottles, iron pieces, etc.

Hazardous waste (RED): For used batteries, children's diapers, sanitary pads, household chemicals / cleaners, fused bulbs / tubes, broken mirror and broken ceramic items, residual paint, indoor and farm pesticides, grease, spray cans, shoe polish, expired medicines and other pharmaceutical items / syringes, needles, sharps, blades, rusted tins, etc.

Material required:

- Containers
- Gloves
- Waterproof boots
- Physical balance (measure mass of waste)
- Waste picker/ tongs
- Survey form
- Observation sheets

Procedure:

I. Household- waste generation and management

Step 1. Identify the source and the type of solid waste generated in a week. You may include three households, two restaurants and a market place as a sample to collect the information in waste generation and disposal practices. Visit the houses before the daily disposal of waste. (Ideal time is early morning or late evening).

Step 2. The information can be collected over a period of time. During the first month, visit each of the three identified household for your study.

Step 3. Carry out a brief survey and collect the information from the three sample household using Survey 1: Solid Waste Generation and Management (Household). Identify the waste and use physical balance to measure the quantity of waste produced every day.

II. Restaurant- waste generation and management

Step 1. During the following month, visit two identified restaurants in the locality and collect information using Survey 2: Solid Waste Generation and Management (Restaurant). Identify the waste and use a physical balance to measure the quantity of waste produced every day.

Step 2. Visit the restaurant before the daily disposal of waste. (Ideal time is early morning).

Step 3. Use gloves and protective gears while handling waste and taking measurements.

III. Market Place- waste generation and management

Step 1. Meet with the community leader or the coordinator of market management committee and find out the existing mechanism of management of solid waste in the community.

Step 2. Use the survey form Survey 3: Solid Waste Generation and Management (Market place and streets) to gather information on the management of waste and its challenges.

Step 3. Compile and calculate the total waste generated using the form Type and Quantity Solid Waste Generated.

Step 4. Go around your community and locate infamous places where wastes are disposed (such as street corners, empty land in between houses, streams and bushes). If possible, take a photograph of these places.

Step 5. Draw a map of your locality and indicate these dumping sites.

Step 6. Draw up a solid waste management (SWM) system project proposal and detail out the programmes, roles and responsibilities of stakeholders and the resource requirement for implementation of SWM system.

Step 7. Discuss and present the proposal to create awareness on the problems of solid waste and pollution with community leaders, shopkeepers and school administrator to seek their support and cooperation in the implementation of SWM system.

Observation

The following form and observation sheets are to be used to collect information on solid waste generation and management.

Survey 1: Solid Waste Generation and Management (Household)

This questionnaire is designed to facilitate the assessment of the current situation of solid waste management practices and awareness in a rural household area. To enable an accurate assessment, it is important that all information in the questionnaire should be obtained as completely and accurately as possible.

Household number: ………………………………

Number of members in a household: ……………………………………

Village: …………………………………

Gewog: …………………………………..

Dzongkhag: ………………………………

Part A: Types and quantity of waste generated

Wet waste: ……………..kg/day
Food waste: …………..kg/day
Dry waste: ……………..kg/day
Hazardous waste: ……………..kg/day

Part B: Waste segregation and disposal

1. Why do you think waste is a problem in your community? *(Tick one that apply)*

		Agree	Disagree	Do not know
a.	It is polluting our surroundings, water sources and fields			
b.	No proper place to dispose the waste			
c.	No knowledge about how to manage waste			
d.	No waste collection services			
e.	Increasing import and consumption of packed foods and electronics			

2. Is the waste increasing in your house? *(Tick all that apply)*
   a. Yes, we consume more packed foods ☐
   b. Yes, we waste lots of food ☐
   c. Yes, we replace old clothes and electronics very frequently. ☐
   d. No, we sell of recyclable waste ☐
   e. No, we reuse containers and improvise waste materials ☐

f. No, we repair electronics, utensils, clothes ☐.
g. No, we compost degradable waste ☐

3. Do you segregate waste before disposal? *(Tick one that apply)*
   a. Yes, dry waste and wet waste ☐
   b. Yes, degradable and non-degradable ☐
   c. Yes, that can be sold, reused and disposed ☐
   d. No, we do not know how to segregate ☐
   e. No, it is all waste anyway. ☐
4. Do you have separate bins for waste? *(Tick one that apply)*
   a. Yes, dry waste and wet waste ☐
   b. Yes, degradable and non-degradable ☐
   c. No, we cannot afford it ☐
5. Where do you dispose your waste? *(Tick all that apply)*
   a. Streams and rivers ☐
   b. Pits at back yard ☐
   c. Fields ☐
   d. Open spaces ☐
   e. Community waste collection services available. ☐
6. What you do with food waste? *(Tick all that apply)*
   a. Feed it to pets ☐
   b. Feed farm animals ☐
   c. Throw away in fields ☐
   d. Dispose together with other waste ☐
7. Do you have place in locality where you sell the recyclable waste? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐
8. Why do you think wastes should be disposed properly? *(Tick all that apply)*
   a. It litters our surroundings ☐
   b. It gives out unpleasant smell ☐
   c. It spreads diseases ☐
   d. It contaminates our drinking water sources ☐
   e. It pollutes streams and rivers ☐
   f. Many wastes are very hazardous and poisonous. ☐
9. Will you like the waste disposal service to be provided? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐
10. Are you willing to pay for it? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐

Survey 2: Solid Waste Generation and Management (Restaurant)

This questionnaire is designed to facilitate the assessment of the current situation of solid waste management practices and awareness by a restaurant in a rural area. To enable an accurate assessment, it is important that all information in the questionnaire should be obtained as completely and accurately as possible

Restaurant name: ……………………………….

Number of customers (Average/day): …………………………………….

Village: ……………………………………

Gewog: …………………………………..

Dzongkhag: ……………………………….

Part A: Types and quantity of waste generated

Wet waste: ……………..kg/day
Food waste: ……….…..kg/day
Dry waste: ……………..kg/day
Hazardous waste: ……………..kg/day

Part B: Waste segregation and disposal

1. Why you think waste is a problem in your community? *(Tick one that apply)*

		Agree,	Disagree	Do not know
a.	It is polluting our surroundings, water sources and field			
b.	No proper place to dispose the waste			
c.	No knowledge how to manage waste			
d.	No waste collection services			
e.	Increasing import and consumption of packed foods and electronics			
f.	Increasing tourist and business operations leading to increase in waste			

2. Is the waste increasing in your restaurant? *(Tick all that apply)*
   a. Yes, customers consume more packed foods ☐
   b. Yes, customers waste lots of food ☐
   c. No, we reuse containers and improvise waste materials ☐
   d. No, we compost degradable waste ☐

3. Do you segregate waste before disposal? *(Tick one that apply)*
   a. Yes, dry waste and wet waste ☐
   b. Yes, degradable and non-degradable ☐
   c. Yes, that can be sold, reused and disposed ☐
   d. No, we do not know how to segregate ☐
   e. No, it is all waste anyway ☐
4. Do you have separate bins for waste? *(Tick one that apply)*
   a. Yes, dry waste and wet waste ☐
   b. Yes, degradable and non-degradable ☐
   c. No, we cannot afford it ☐
5. Where do you dispose your waste? *(Tick all that apply)*
   a. Streams and rivers ☐
   b. Pits at backyard ☐
   c. Fields ☐
   d. Open spaces ☐
   e. Community waste collection services available. ☐
6. What you do with food waste? *(Tick all that apply)*
   a. Feed it to pets ☐
   b. Feed farm animals ☐
   c. Throw away in fields ☐
   d. Dispose together with other waste ☐
7. Do you have place in locality where you sell the recyclable waste? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐
8. Why do you think wastes should be disposed properly? *(Tick all that apply)*
   a. It litters our surroundings ☐
   b. It gives out unpleasant smell ☐
   c. It spreads diseases ☐
   d. It contaminates our drinking water sources ☐
   e. It pollutes streams and rivers ☐
   f. Many wastes are very hazardous and poisonous ☐
9. Will you like the waste disposal service to be provided? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐
10. Are you willing to pay for it? *(Tick one that apply)*
   a. Yes ☐
   b. No ☐

Survey 3: Solid Waste Generation and Management (Market place and streets)

This questionnaire is designed to facilitate the assessment of the current situation of solid waste awareness and management practices in a market place in a rural area. To enable an accurate assessment, it is important that all information in the questionnaire should be obtained as completely and accurately as possible.

Village: ……………………………………

Gewog: …………………………………..

Dzongkhag: ………………………………

Population of community: ………………………………

Part A: Types and quantity of waste generated

Wet waste: ……………..kg/day
Food waste: …………..kg/day
Dry waste: ……………kg/day
Hazardous waste: ……………kg/day

Part B: Waste segregation and disposal

1. Why do you think waste is a problem in your community? *(Tick one that apply)*

	Agree,	Disagree	Do not know
a. It is polluting our surroundings, water sources and fields.			
b. No cooperation among vendors and people to manage waste			
c. No waste collection services in place			
d. Increasing import and consumption of packed foods and electronics			
e. Increasing tourist and business operations leading to increase in waste			

2. Is the waste increasing in the market place? *(Tick all that apply)*
   a. Yes, people consume more packed foods ☐
   b. Yes, people consume and discard more items than before ☐
   c. No, we advise people to reuse containers and improvise waste materials ☐
   d. No, people compost degradable waste and sell off recyclable waste. ☐

3. What are the challenges faced to manage wastes? *(Tick all that apply)*
   a. Lack of awareness of wastes and its impact among people. ☐
   b. Operational cost, maintenance and resources for solid waste management ☐
   c. Poor practice and civic sense ☐
   d. Technical expertise ☐
4. Why do you think wastes should be disposed properly? *(Tick all that apply)*
   a. It litters our surroundings ☐
   b. It gives out unpleasant smell ☐
   c. It spreads diseases ☐
   d. It contaminates our drinking water sources ☐
   e. It pollutes streams and rivers ☐
   f. Many wastes are very hazardous and poisonous. ☐
5. What should be done to manage wastes and keep the community clean? *(Tick all that apply)*
   a. Solid Waste Management System Plan needs to be developed ☐
   b. Community education and awareness on solid waste management ☐
   c. Area survey and planning for centralised sanitary landfill. ☐
   d. Infrastructure, technical and human resources planning and execution. ☐
   e. Implementation of solid waste management system. ☐
   f. Feedback and monitoring system ☐

Type and Quantity of Solid Waste Generated

Village: ……………………………………

Gewog: …………………………………..

Dzongkhag: ………………………………

Type and amount of waste generated

Sl No	Source	Type and quantity (kg/day)			Amount of waste (kg/day)	Average amount of waste (Avg)	Number of sources in the community (n)	Total Amount of waste (n x Avg)
		Wet Waste	Dry Waste	Hazardous Waste				
1	House 1							
2	House 2							
3	House 3							
4	Restaurant 1							
5	Restaurant 2							
6	Market Place and streets							
							Total waste	

Result

1. The total waste generated by the community in a day= .... kg
2. Map (sample) in Figure 5.2 shows the dumping sites in the locality

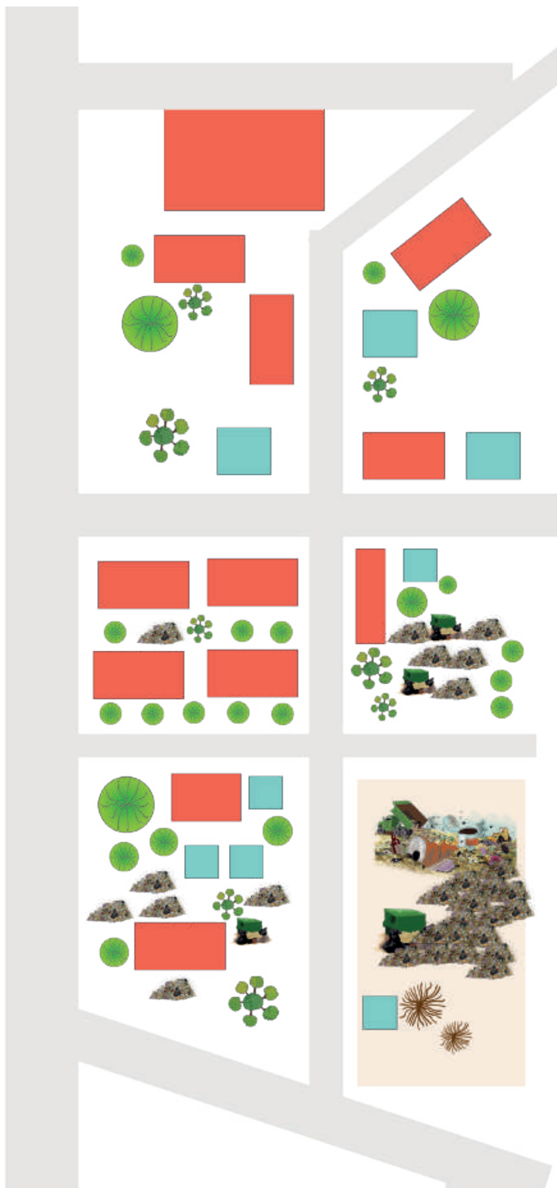


Figure 5.2. Map of a locality showing the waste dumping places and disposal sites

3. Write a proposal to establish SWM system. You may use the following template to write the proposal

Proposal format for SWM system

Village: ……………………………………

Gewog: …………………………………..

Dzongkhag: ……………………………….

1. ***Rationale:***
   - Describe the purpose for SWM system
   - Why is there a need of SWM system in place?
2. ***Outcome:***
   - Describe the expected outcome of the project.
3. ***Project requirements and implementation:***
   - Describe what is proposed (provide a diagram) and how can solid wastes be managed?
   - What facilities are required? (Land, Infrastructure, transportation, etc.)
   - What equipment and tools are required? Justify each equipment and tool required (e.g. wheel barrow, containers, waste bins, spades, etc.)
   - Where will the facilities and sanitary disposal site be set up?
   - How to prepare the community?
   - Outline the responsibility of each stakeholder (household, shop, restaurant, municipal, etc.)
   - How to equip the local administrators to take up this new task (SWM)
   - Mechanism of Operation (Technical Plan)
     - Additional human power requirement
     - Collection Arrangement
     - Transport
     - Treatment of wastes
     - Disposal
4. ***Financial Requirements***
   - Fixed (One-time) Investment Requirement (List the requirements with budget)
   - Monthly Operation Expenditure
   - What is the plan for sustainable Operation and Maintenance of the Project?
     - Inspection, monitoring and support
     - Payment for services
     - Non-compliance of rule and penalty

Conclusion

Urbanisation is rapidly taking place in the community. Consequently, there is a huge increase in consumption of packed food items and modern amenities like clothes, electronics, plastic containers, etc. The total amount of waste produced by the ………………….. (name of community) community is ……….. tonnes in a month. At this rate, a metre high solid waste will cover an area of ………….. m^2 in a year. Careless disposal due to absence of systematic management of waste is noticeable in the community. The lack of knowledge on waste segregation and practices has contributed significantly in polluting the environment. The infamous waste disposal sites are……….. (streams, rivers, forest, street corners, public land spaces, etc). These places are especially vulnerable and be sources for contaminated drinking water, provide perfect conditions for the spread of diseases.

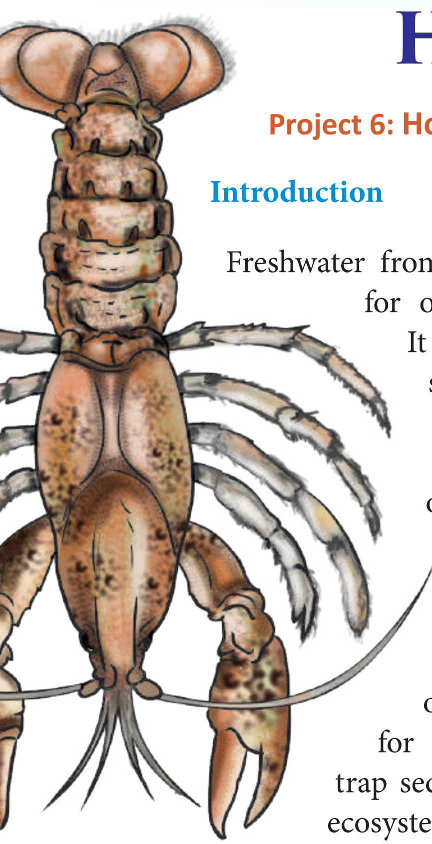
Efforts to manage waste have been made earlier, however, they have failed due to insufficient awareness, weak management, monitoring and support systems. People should be more responsible and contribute equally in managing wastes. The community administration should provide continuous and regular awareness programmes, disposal facilities, carryout monitoring and collect feedback for improvement of the system.

The proposed SWM system is suitable in managing the waste in our locality.

Safety!

- Wear gloves and use appropriate tools while handling and measuring wastes.
- Be careful of sharp objects and broken glasses. Pick waste only with waste pickers.
- Handle all the hazardous waste carefully.
- Wash your hand immediately after handling waste.
- Do not eat or drink while handling waste.

Sample Projects
(Grade IX to XII)



Healthy Stream

Project 6: How do you determine streams are healthy?

Introduction

Freshwater from streams, ponds, lakes, springs and rivers is essential for our physical, social, economic and cultural wellbeing. It provides safe drinking water, recreational activities, such as boating, fishing and swimming, and water for sanitation and hygiene. It is also extensively used in farming, irrigation of crops and pastures and production of hydroelectricity. Bhutanese also have cultural, historical and spiritual connections with many of the country's springs, wetlands, rivers and lakes. In a watershed, streams are the pathways that transport water through a watershed which is critical to the healthy functioning of the watershed. Streams provide uncountable habitats for biological communities downstream, control flood, trap sediments, recycle nutrients and ensure the stability of an ecosystem. Pools, riffles and runs are the three main types of habitat in a stream. A pool in a stream is an area of slow-flowing, deep water usually formed on the outside bend of a stream. Stream in mountains are characterised mostly by riffles which is an area of fast, shallow water, flows over stones which break the surface of the water. A run in streams is a smooth, unbroken flow of water that connects pools and riffles. A combination of these types of habitat provides a suitable habitat to thousands of flora and fauna.

Streams and rivers are highly vulnerable to change caused by human activities. According to studies there are five major threat categories to freshwater biodiversity: overexploitation, water pollution, flow modification, destruction or degradation of habitat, and invasion by exotic species. The management of streams and rivers is one of the challenges to be tackled by present and future generations. The sustainable use of water resources and the maintenance of good water quality, both sanitary and environmental, is essential and it depends largely on the conservation of biodiversity. One of the predictable effects of climate change and poor management of water sources is the drying up of streams or the transformation of streams from permanent to seasonal streams.

Therefore, it is crucial to monitor the health of stream regularly to mitigate the impact of human activities and pollution. The health of the stream is determined by investigating and examining its physical, chemical and biological characteristics.

Background

Human civilisation has always developed along the banks of rivers and streams. Today the landscape has been transformed and most waterways pass through towns and farmland. Human activities often cause severe ecological damages to river systems. These disturbances produce alterations in the physical characteristics, chemical composition of water, and in the structure of the communities of organisms living in this environment. River and streams are contaminated by various types of pollutants such as, herbicides, pesticides, depositions from oil and gas, heavy metals, worldwide due to increasing urbanisation and industrialisation. It has resulted in biodiversity loss and poor water quality. Sewage and fertilisers drain off into streams and provide nutrients that promote the rapid growth of algae in streams. When algae die in large quantities and decompose, bacteria consume oxygen and make it unavailable to macroinvertebrates and other aquatic species. Changes in land use involving removal of natural vegetation and poorly protected cropland expose soil to erosion and add sediment to the water clouding it, clogging gills and making it more difficult to find food. It also destroys habitats by smothering the rocky areas of the stream where organisms live.

The presence or absence of particular plants and animals tells us a lot about the health of a stream. Different groups of macroinvertebrates are excellent indicators of human impacts, especially contamination of streams. Most of them have quite narrow ecological requirements and are very useful as bioindicators in determining the characteristics of aquatic environments. The health of the local streams is examined based on bioindicators.

Method

Students collect macroinvertebrates from a local stream. They identify and categorise the species collected, and use the result to calculate a water quality index for the stream.

Aim: To determine the health of a local stream by studying the presence of macroinvertebrates.

Hypothesis: The health of the stream, and the life within is excellent / good / poor.

Theory:

Macroinvertebrates are animals that are visible to the naked eye (macro) and do not have backbones (invertebrate). Macroinvertebrates include larval stages of insects, aquatic worms, snails, clams, and crustaceans (crabs, crayfish, shrimp). Macroinvertebrates generally resides at the bottom of streams, and cannot swim away like fish to escape pollution, therefore, they are quite vulnerable to pollution. A small alteration to the stream has a great impact on the abundance and distribution of different macroinvertebrate types. Many macroinvertebrates have short life cycles, usually one season or less, making it ideal to complete the study in a short period of time. Some insects such as flies, beetles and caddisflies go through a complete metamorphosis, from their life as an egg, hatching into a larva, transforming into a pupa and eventually emerging as a winged adult. Other insects such as dragonflies, stoneflies and mayflies undergo a less complex series of changes called incomplete metamorphosis, skipping the pupal stage. The larva of insects which undergo incomplete metamorphosis are sometimes called nymphs. Most aquatic insects like mayflies spend the greater part of their lives as larvae and live only a few hours as an adult. After spending most of their life eating and growing as a larvae, adult insects must quickly mate and deposit their eggs before they die to begin a new cycle.

Macroinvertebrates are an intermediate link in the streams food chain between higher and lower feeding levels. Some macroinvertebrates are herbivores, while others are carnivores, feeding on other macroinvertebrates, and even small fish and amphibians. A group of macroinvertebrates called detritivores, feed on organic material that fall into and carried through the stream habitat. Macroinvertebrates in all feeding groups recycle nutrients in the stream ecosystem.

Generally, macroinvertebrates are categorised into three groups based on their tolerance to pollution.

Group I (sensitive organisms)

This group includes pollution- sensitive organisms which are typically found in good-quality water, such as caddisfly larvae, hellgrammite, mayfly nymphs, gilled snails, riffle beetle adult, stonefly nymphs and water penny.

Group II (somewhat sensitive organisms)

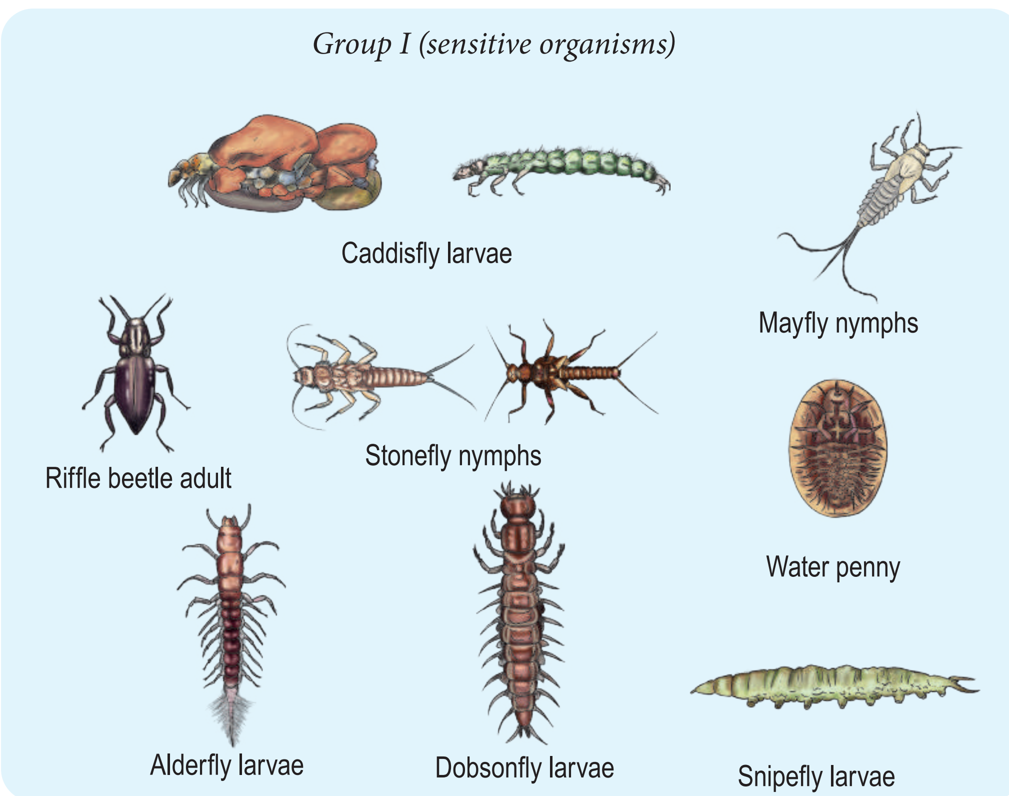
This group includes macroinvertebrates that are somewhat pollution-tolerant generally found in fair-quality water, such as beetle larvae, clams, cranefly larvae, crayfish, damselfly nymphs, dragonfly nymphs, scuds, sowbuds, fishfly larvae, alderfly larvae and atherix.

Group III (tolerant organisms)

These macroinvertebrates are pollution-tolerant organisms, which are even found in poor quality water, such as aquatic worms, leeches, blackfly larvae, lunged snails and midge larvae.

The presence of sensitive species that are intolerant to pollution in a stream suggests that the stream is in a healthy conditions. Assessing the presence or absence of tolerant and intolerant types together can indicate the overall health of a stream. The number of individuals of each species is counted and is represented in percentages to document health of the stream in a quantitative manner.

Macroinvertebrate identification chart.



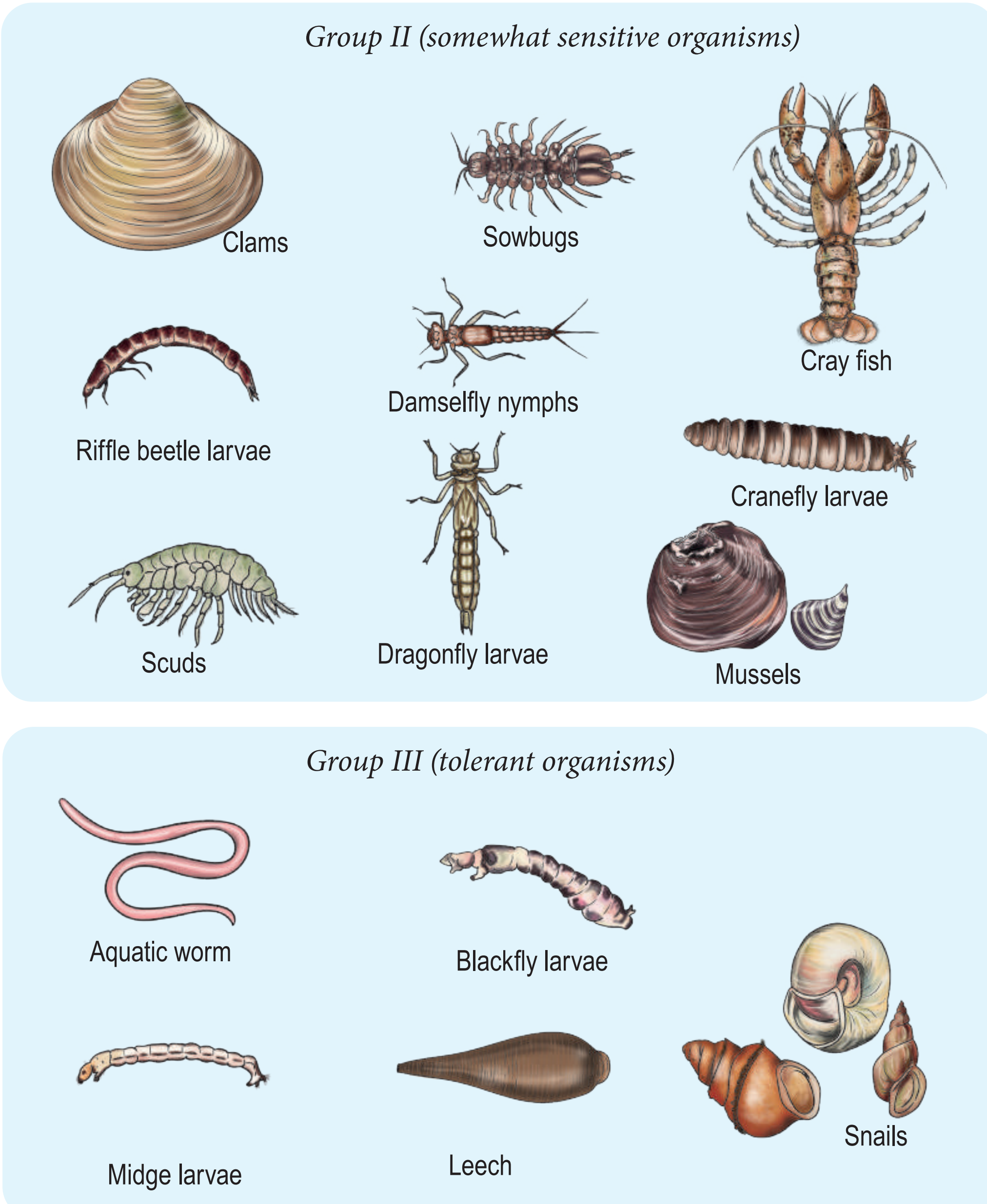


Figure 6.1. Macroinvertebrates groups

The method to collect macroinvertebrates depends on the type of stream you are sampling and accordingly locations of sample sites are identified. There are basically two types of streams.

a. *Rocky-bottom streams.* The bed of these streams are made up of a combination of gravel, cobbles, and boulders and usually have definite riffle areas. Riffle areas are fairly well oxygenated and, therefore, are prime habitats for macroinvertebrates.

b. *Muddy-bottom streams:* These streams have a bed that contains mud, silt, or sand and lack riffles. Generally, these streams are slow moving, low-gradient streams. In such streams, macroinvertebrates generally attach themselves to overhanging plants, roots, logs, submerged vegetation, and stream substrate where organic particles are trapped.

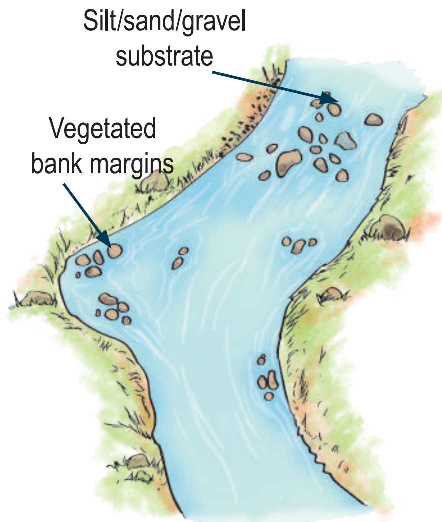


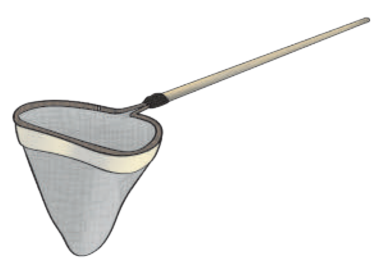
Figure 6.2. Rocky- bottom streams

Material required:

1. Equipment (Safety)

- Gumboots
- Metre stick for balance, probing, and measurement
- Thorn-resistant clothes
- Rubber gloves
- Safety goggles
- Insect repellent/sunscreen
- Small first aid kit, flashlight, and extra batteries
- Whistle to summon help in emergencies
- Refreshments and drinking water
- Information sheet (safety instructions, site location information, and emergency numbers)

2. Equipment (Experiment and observation)



- Macroinvertebrate identification chart
- Macroinvertebrate survey sheet
- Clipboard, preferably with plastic cover
- Pencils
- Measuring tape (0-100 m)
- Kick net
- D-frame net

- White plastic ice-cube trays
- Buckets
- Tweezers or forceps
- Magnifying glass
- Plastic scooper/ ladle
- String balls/ twine thread
- White shallow plastic trays
- Wash bottle
- Jug
- Eye dropper
- Calculator (optional)
- Camera (optional)



Procedure:

Prepare for the field work

Step 1. Know all about macroinvertebrates' habitat and their life cycles before the field trip.

i. Take copies of the handouts and observation sheets.

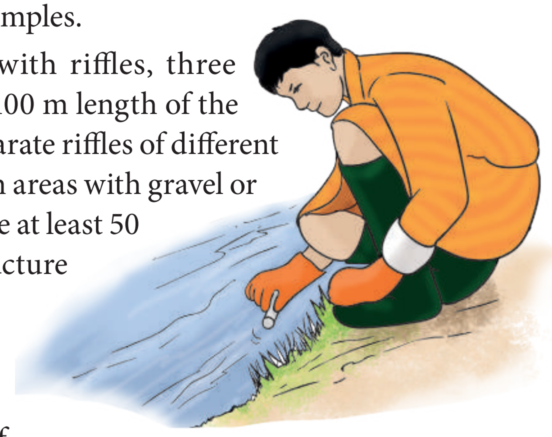
ii. Carry all the equipment required to collect sample and take measurements at stream site.

iii. Be thorough with safety rules and wear safety gears for the field work.

iv. Determine the time of the survey.

Step 2. Identify location or sites to collect the samples.

i. In case of rocky-bottom streams with riffles, three different spots are selected within a 100 m length of the stream. These spots may be three separate riffles of different sizes or combination of riffles and run areas with gravel or cobble substrates. These spots must be at least 50 m upstream of any human-made structure like bridges, pipelines, dam etc.



ii. In case of muddy-bottom streams, all types of habitats are selected if available or if not the type of habitat that is productive is determined. Depending on the types of habitat, the number of jab determines the collection of organisms.

Precaution!

Avoid standing in the stream while making your habitat determinations

Step 3. Sketch your sampling site.

a. Rocky-bottom streams sampling location

Sketch the 100 m sampling area. Clearly indicate the location of your three sampling spots on the sketch. Mark the most downstream site as Site 1, the middle site as Site 2, and the upstream site as Site 3.

b. Muddy-bottom streams sampling location

Muddy-bottom streams usually have four types of habitats, but not all habitats are present in all streams, and all habitats may not host a wide variety of organisms. The most abundant type of habitat is the vegetated bank margins. It consists of overhanging bank vegetation and submerged roots, decomposing leaf packs trapped in root wads or lining the stream banks. Another productive habitat are snags and logs that is primarily characterised by submerged dead trees, logs, branches and roots with leaf packs lodged between rocks or logs.

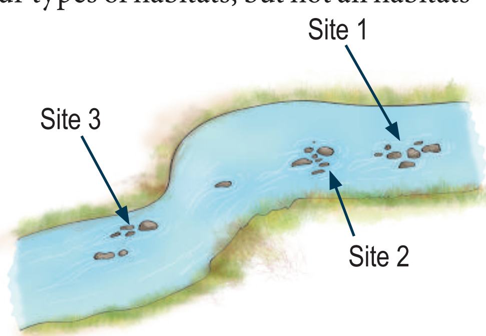


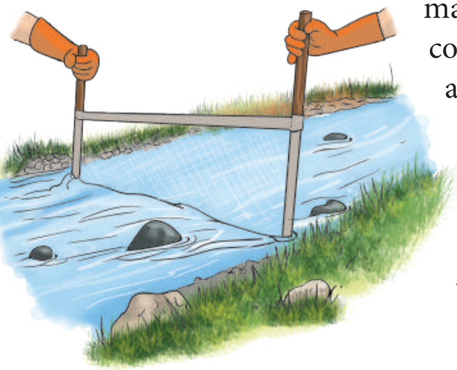
Figure 6.3. Rocky-bottom sampling site

Aquatic vegetation beds and decaying organic matter form the third type of habitat consists of green/leafy plants attached to the bottom of stream. The last type of habitat is made up of sandy, silty, or muddy stream bottoms; rocks along the stream bottom; and/or wetted gravel bars; and algae-covered rocks. This is the least productive of the four muddy-bottom stream habitats. Select and mark the habitat for sampling as Habitat 1 to Habitat 4.

Step 4. Collect Macroinvertebrates

Depending on the type of stream that is sampled, the following methods are used to collect macroinvertebrates. To locate macroinvertebrates in the stream, use one or more of the following methods.

a. Kick-sampling method



Kick-sampling method uses kick-nets to collect macroinvertebrates. It is an effective method for sample collection in rocky-bottom streams. The sampling locations are approached from the downstream end and sample Site 1. The net is inserted into the water at Site 1 and held at 45° angle to the water. To prevent debris and escape of organisms, a medium sized rock may be placed at the bottom to hold down the net. Do not allow any water to flow over the net.

1. Approach the sample site from downstream

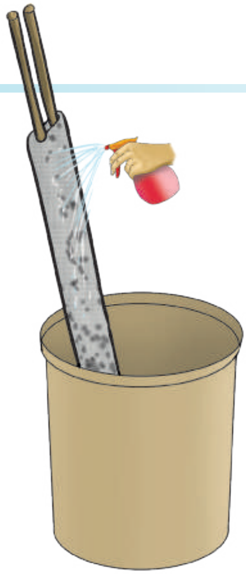
2.Position the net at 45° angle with button fixed at the substrate

3. Disturb the substrate with your foot

4. Remove the net at forward scooping motion

Figure 6.4. Kick-Sampling method

After the net is placed, disturb (with foot, kicking motion) the area just upstream of the net for about three minutes. The dislodged



animals will then be carried downstream by the current into the net. Next, remove the net. Gradually, forward scoop and remove the net from the stream without losing any of the organisms it contains. Roll the net into a cylindrical shape and place it vertically into a bucket half filled with water. Flush the contents of the net into the bucket by pouring or spraying water using a wash bottle. If necessary, pick debris and organisms from the net using your hand. Release back any fish, amphibians or reptiles caught in the net. Repeat the steps for Site 2 and Site 3. The kick-net method is shown in Figure 4.

b. D-Frame net sampling method

In muddy-bottom streams, identify the most productive habitats available and look for the widest variety of organisms. The most productive habitats are the ones that have a diverse population of pollution sensitive macroinvertebrates. The process is to jab at the habitat and scoop up the organisms and debris dislodged using a D-frame net. The total numbers of jabs to be made is 20. The number of jabs to be made in each type of habitat depend on the availability of types of suitable areas in muddy-bottom streams. It is important to note the number of jabs for each type of habitat and it must be recorded in the field data sheet. General guideline for the number of jabs to be made are as follows:

- In the presence of all four types of habitats, jab the vegetated banks 10 times and divide the remaining 10 jabs among the remaining 3 habitats.
- If only three habitats are present, jab the silt/sand/gravel substrate habitat 5 times and divide the remaining 15 jabs among the other two more productive habitats.
- In the presence of only two types of habitats, jab the silt/sand/gravel substrate 5 times and the more productive habitat 15 times.
- Take only one or two jabs in case some habitats are plentiful and others are sparse, Take the remaining jabs from the plentiful habitats. This also applies to the situation when some habitats cannot be reached due to unsafe stream conditions.

Precaution!

Be careful as there may be glass, metal or other sharp objects on the riverbed.

c. Log-rubbing method

This method of sampling requires only one person to disturb the stream habitat. After every required number of jabs, rinse the contents of the net into the bucket with half-filled stream water. In case of vegetated bank margins, jab vigorously, in upward motion, brushing the net against vegetation and roots along the bank. The entire jab motion should occur underwater. Similarly, while sampling aquatic vegetation beds, jab vigorously, in upward motion, against or through the plant bed. To sample snags and logs, rub about 30 square centimeter of area on the snag or log with one hand, while holding the net under water under the section of submerged wood. Scoop organisms, bark, twigs, or other organic matter you dislodge into your net. Each combination of log rubbing and net scooping is considered as one jab. In case of a silt/sand/gravel substrate habitat, place the net with one edge against the stream bottom and push it forward in an upstream direction about 30 cm. To rinse out the fine silt and mud on the net, sweep it slowly, back and forth under water. If necessary, pick any clinging organisms from the net by hand and put them in the bucket.

d. Rock-rubbing method.

This method is ideal in streams with riffle areas and rocky bottoms. Select five rocks randomly to remove from within a riffle area of your stream site. One rock from each side of the stream, one rock from the middle and two rock from in between the middle and the side of the stream. Each rock should be about 4-6 inches in diameter and are submerged during normal flow of water in the stream. Inspect for living organisms and pick up from the rock's surface or place the rock in a white and shallow plastic tray, pour some water and brush the rock's surface gently using a soft bush to remove clumps of gravels or leaves (house for insects).

e. Stick-picking method.

This method is effective in streams without riffle areas and rocky bottoms. Collect several short sticks of approximately 5 cm in diameter from inside the stream site, and place them in a bucket filled with stream water. Remove one of the sticks and place it in a shallow plastic tray containing stream water. Examine loose bark or crevices on the stick to locate organisms. You may break the sticks to look inside the stick. Remove anything that resembles a living organism and place it in the tray using tweezers or a soft brush, carefully. Do not forget to look into the contents of the bucket as it may have some organisms fallen off the sticks.

Precaution!

Always use gloves and tweezers while handling organisms and debris

f. Leaf pack-sorting method.

Remove several handfuls of submerged leaves from the stream with or without a rock bottom and place them into a bucket. Remove the leaves one at a time and look closely for the presence of insects. Remove anything that resembles a living organism and place it in the tray containing stream water using tweezers or a soft brush, carefully. Do not forget to look into the contents of the bucket as it may have some organisms fallen off the leaves.

Step 4. Sort macroinvertebrates

Handle the organisms and debris carefully all the time. Look for anything that swims, crawls, or appears to be hiding in a shell, like a snail. You may use magnifying glasses to locate small organisms. Use tweezers, eye dropper or spoon to pick organisms. Sort similar organisms into the ice-cube tray.

Step 5. Identify macroinvertebrates and rate the stream's health.

i. Using the hand lens or magnifying glass and Macroinvertebrate Identification Chart, carefully observe the collected organisms.

ii. Refine your initial sort so that similar organisms are placed in the same section(s) of the ice cube tray.

iii. If you cannot identify an organism, place one or two specimens in the alcohol-filled vial for identification later.

iv. On your field data sheet Macroinvertebrate Survey Sheet, note the number of organisms identified into three categories: sensitive organisms, somewhat sensitive organisms and tolerant organisms).

v. When you finish identifying all the organisms, return the macroinvertebrates to the stream.

vi. Rate the quality of the water in the stream.

Observation

The field data sheet 'Macroinvertebrate Survey Sheet' is used to record the observation and calculate the water quality index. You should carefully identify macroinvertebrates using Macroinvertebrate identification chart.

Macroinvertebrate Survey Sheet

School: ....

Date: ....

Name of the stream: ....

Location: ....

1. Stream type and method

Type of Stream: …………………………… (rock-bottom/muddy bottom)

Rock Bottom Site:

Site 1:..

Site 2::...

Site 3::...

Muddy-Bottom Habitat:

Habitat 1: ……………………………………

Habitat 2: …………………………………..

Habitat 3: ……………………………………

Habitat 4: …………………………………….

Sampling method 1: ....

Sampling Method 2: ....

Sampling Method 3: ....

2. Macroinvertebrates Observation

Check the organism found by ticking the box. Count and write the number of organisms against the name of each organism under respective groups.

Sensitive			Somewhat Sensitive			Tolerant		
Presence	Organism	Count	Presence	Organism	Count	Presence	Organism	Count
☐	Caddisfly larvae		☐	Clams		☐	Aquatic worms	
☐	Mayfly nymphs		☐	Sowbugs		☐	Blackfly larvae	
☐	Riffle beetle adult		☐	Crayfish		☐	Midge larvae	
☐	Stonefly nymphs		☐	Cranefly larvae		☐	Leech	
☐	Water penny		☐	Riffle beetle larvae		☐	Lunged snails	
☐	Aderfly larvae		☐	Damselfly nymphs				
☐	Dobsonfly larvae		☐	Dragonfly nymphs				
☐	Snipefly larvae		☐	Scuds				
			☐	Mussels				

Result

Calculate the water quality index and determine the health of the stream using the following sheet.

Water quality index Sheet

Organisms	Number of types	Weighting factor	Group Score
Sensitive		X 3	
Somewhat sensitive		X 2	
Tolerant		X 1	

Total group score (add up the group scores from all the rows)	
Total number of types of organism (add up the number of types from all rows)	
Water quality index (total group score ÷ total number of types of organism)	

Total Number of Sensitive Organisms = ...
Total Number of Somewhat-Sensitive Organisms = ...
Total Number of Tolerant Organisms = ...

Conclusion

To draw the conclusion on the water quality and the condition of the stream, the following indicator is used.

INDICATION OF STREAM CONDITION FOR YOUR MONITORING SITE

Ratings	Condition
If less than or equal to 100 macros present and Water quality index >3.6	Poor
If less than or equal to 100 macros present and Water quality index is 2.6 – 3.5	Fair
If more than or equal to 100 macros present and Water quality index is 2.1 – 2.5	Good
If more than or equal to 100 macros present and Water quality index is 1.0-2.0	Excellent

The health of the stream is found to be ……………………….. This is evident from the existence of over/only ……………… (number) macroinvertebrates and the water index calculated is …………..

The result --------------- (is/is not) as predicted as .... (write reasons) .

The error in the measurement is minimal as all the scientific processes were strictly followed to gather the data on the stream. However, the observations were carried out during .... season. It is known that the population and life cycle of the macroinvertebrates is dependent on seasons and climatic conditions and their availability is determined by weather conditions like rainfall. Therefore, all the macroinvertebrates may not have been available during my observation period. The health of the stream can be generalised to a certain extent. However, samples were from a section of the stream and collected only once.

The findings can be strengthened with data from the study of the physical and chemical conditions of the stream water. As mentioned earlier, the health of the stream is fully determined by investigating and examining some of its physical, chemical and biological characteristics. Therefore, further examination and study of the physical and chemical characteristics of the stream are recommended.

Safety!

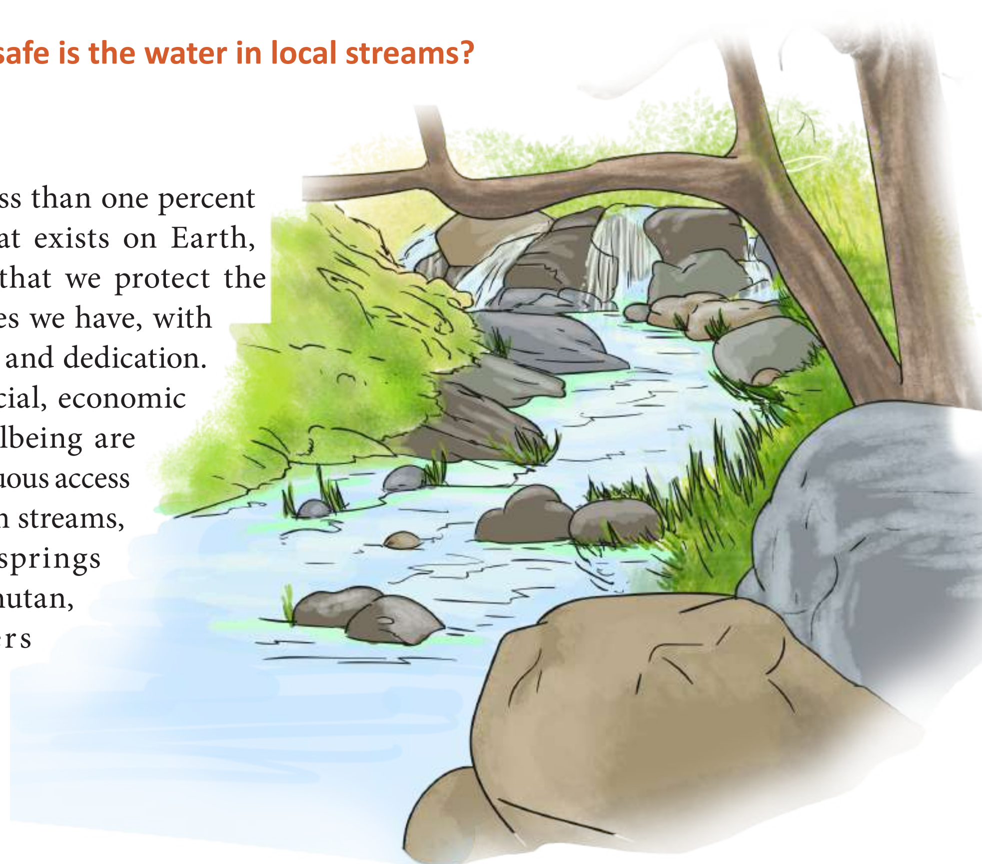
One of the most critical considerations for a stream water survey is the safety of oneself. At the site:

- Always work with at least one partner. A team of three or four people are best.
- Always let someone else know where you are.
- Never go sampling if severe weather is predicted or if a storm occurs while at the site.
- Do not sample the stream when it is at flood stage.
- Do not attempt to cross streams that are swift and above the knee in depth.
- Watch for wildlife (particularly snakes), and insects such as ticks, hornets, and wasps, and plants like poison ivy, poison oak, and nettle plant can cause rashes and irritation.
- Be very careful of slippery rocks and surfaces, deep pool and sinkholes when walking in the stream itself.
- Always wear gumboots and rubber gloves in streams while sampling.

FRESHWATER QUALITY

Project 7: How safe is the water in local streams?

Introduction



With access to less than one percent of freshwater that exists on Earth, it is imperative that we protect the freshwater sources we have, with full commitment and dedication. Our physical, social, economic and cultural wellbeing are ensured by continuous access to freshwater from streams, ponds, lakes, springs and rivers. In Bhutan, streams, rivers and springs are the three main sources of water for drinking, farming and irrigation, recreational activities, such as boating, fishing and swimming, water for sanitation and hygiene. We are also heavily dependent on our rivers to produce hydroelectricity. Streams provide uncountable habitats for biological communities downstream, control flood, trap sediments, recycle nutrients and ensures the stability of an ecosystem.

Water is a universal solvent. Therefore, every human activity affects the water quality, starting from the atmospheric gases to the waste we produce every day. Water dissolves a broad range of solid, liquid and gas which can alter its characteristics. The level of dissolved carbon dioxide and oxygen that is vital for aquatic life is affected by the growth of high levels of algae and undissolved solids that block the sunlight. The fertilisers (natural and chemical), household waste, human faeces, animal wastes and industrial wastes change the nutrient level and pH of water. They make water increasingly toxic and unfit for use and survival of aquatic life, and result in other undesirable consequences.

Water quality informs the health and vitality of hundreds of local ecosystems and habitats. Therefore, regular monitoring of water bodies can help us understand how the biological, physical and chemical characteristics of water changes. Stream quality monitoring is an important component of any environmental management scheme, especially on sites where human activities may impact water quality.

Visual surveys, macroinvertebrate surveys, water physical characteristics of water testing, and chemical test of water are the basic types of water quality monitoring. Visual surveys are simple to carry out and require no equipment. It identifies the problems that can be further investigated and tested accurately. It includes basic indicators such as colour, odor, surface coatings, and shoreline characteristics to assess water quality. Macroinvertebrate surveys assess the abundance and diversity of aquatic organisms present to determine water quality. These tests are also highly accurate and inexpensive. Testing dissolved oxygen, pH and conductivity, are good indicators of water quality. These are the physical characteristics that can be tested using basic laboratory equipment and the results can be easily interpreted. Specific chemical tests are carried out to find the level of nitrogen, phosphorus, or other dissolved salts in water. It demands scientific skills and involves relatively complex chemical analysis.

The results of these tests provide information on the state of our freshwater resources. It also gives insight into the effectiveness of current management practices and how we can protect existing freshwater resources to mitigate its impacts.

Background

Certain chemicals are harmful to plants, animals and humans. The presence of these harmful chemicals in streams often provide visual clues such as bubbles, strange colour and presence of dead organism. Sometimes, water may appear clean and healthy, but it may contain chemicals at a very high level that is a threat to aquatic life and humans. The case is no different for our local streams and rivers as well. Human activities, even in rural places have increased over the years and these places are more vulnerable as the water body is often not managed. The exploitation of natural resources is not sustainable and wastes are often disposed into streams.

In rural Bhutan, most people rely on private water supplies from streams and springs. The suitability of water for livestock, watering, irrigation, spraying, or drinking needs to be examined to reduce risks and undesirable consequences. Tests for faecal coliform bacteria such as E.coli are often carried out to check the suitability of water. In rural settings, these bacteria are mainly spread by bird and animal faeces. Agriculture is more prominent in rural areas and the use of fertilisers has increased, thereby increasing the entry of pollutants and nutrients into streams generally through agricultural runoffs. This has led to eutrophication and contamination of streams. Drainage from sewage pipe into the stream is also a common scenario which further contaminates the water, accumulating lead, cadmium, zinc, mercury, iron, nickel, and copper. These pollutants have differing affects on organisms including damage to fish gills and death of aquatic organisms. Also, mines are normally found more in rural areas. The mine drainage contains acids, heavy metals and iron that eventually enter streams. These change the pH of water and can severely harm aquatic life. A potential cause of water source pollution are landfill sites. The water in waste and the rainwater that passes through the waste picks up all the pollutants, such as heavy metals, ammonia and oxygen depleting pollutants, along the way. If this contaminated water reaches uncontaminated the water bodies, it could severely harm organisms that are dependent on streams and other water bodies.

Therefore, water quality sampling and testing allows us to establish knowledge and understanding of the specific issues of our local streams. The results of testing can provide up-to-date information and help in determining the best course of action to take to manage water resources appropriately. The parameter values such as alkalinity and conductivity indicate that something may be imbalanced leading to an unhealthy stream. The amount of dissolved oxygen helps to determine what species of fish and other organisms can survive in the water. Assessment of levels of nitrogen and phosphorus give us the ability to rate healthy waterbodies and anticipate potential future issues that may arise as a result of poor water quality.

Method

Students use various tools and methods to carry out water quality test that includes visual surveys, water physical characteristics testing and chemical test on water.

Aim: To carry out visual, physical and chemical test on water from local stream which is the source of water for the locality.

Hypothesis: The water from the stream in our locality is safe/ unsafe for use and for the aquatic life.

Theory:

The parameters commonly monitored are dissolved oxygen and biochemical oxygen demand, temperature, pH, turbidity and nitrates.

Temperature:

Temperature directly affects many physical, biological and chemical characteristics of a waterbody. The rate of photosynthesis and bacterial decomposition in warm waters are high as it is susceptible to a build-up of nutrients and possible algal growth. Green algae blooms above 25°C and blue-green algae blooms at 30°C. Oxygen dissolves less in warm water, while salts are more soluble in warmer water affecting the water's salinity. Fluctuations in water temperature lead to poor functioning of aquatic organisms and they become more susceptible to toxic wastes, parasites and diseases. With extreme temperature change, many organisms will die. The temperature change is usually caused by changing weather, removal of stream bank vegetation, building of dams, storm water, etc.

pH:

pH (Potential of Hydrogen) of a solution is a measure of acidity and alkalinity on a scale of 0 to 14. The pH scale measures the logarithmic concentration of hydrogen (H^+) and hydroxide (OH^-) ions, which makes up water ($H^+ + OH^- = H_2O$). When both types of ions are in equal concentration, the pH is 7.0 or neutral. A pure water is neutral which has a pH of 7. Below 7.0, the solution is acidic (there are more hydrogen ions than hydroxide ions). When the pH is above 7.0, the solution is alkaline, or basic (there are more hydroxide ions than hydrogen ions). Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity. So, a water sample with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0, and pH 4.0 is 100 times as acidic as pH 6.0.

Generally, water in any stream is a solution as it contains dissolved minerals and substances. The largest variety of aquatic plants and animals are adapted to a particular pH range, usually between 6 to 8. They may become stressed or die if the pH is below 6 or above 8. pH also affects many chemical and biological processes in the water. Rainfall, time of the day, amount of algae or plants, geology, storm water pollution and salinity are some factors that affects the pH of stream water.

pH	pH level	Conditions
<5.5	High acidity	Most freshwater animals and plants will die
5.5	Medium acidity	Possible pollution problems
6 - 8	Normal pH	Healthy level for aquatic animals and plants
8.5 - 9	Medium alkalinity	Possible pollution problems
>9	High alkalinity	Most freshwater animals and plants will die

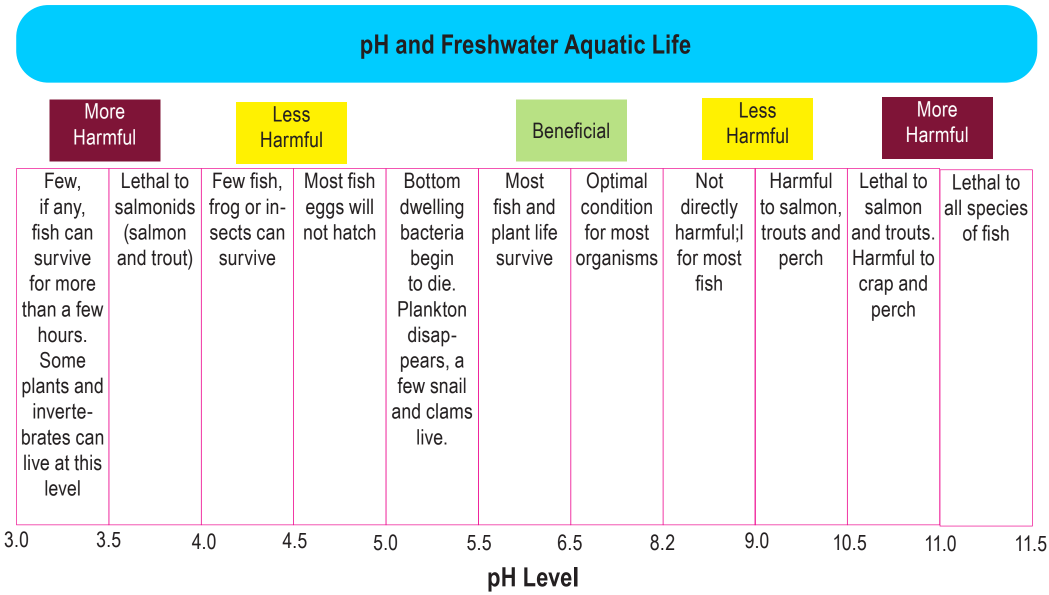


Figure 7.1. Effects of pH on freshwater aquatic life

Turbidity:

Turbidity is a measurement of water clarity. It determines how cloudy, dirty or muddy the water is. Pollutants and particles such as clay, silt, sand, algae plankton and microbes can increase turbidity. It changes the colour of water and restricts light penetration that reduces photosynthesis reducing plant growth. Turbidity also increases water temperature, which in turn reduces concentration of dissolved oxygen. Suspended materials in turbid water can clog gills of organisms, and affect egg and larval development of macroinvertebrates. Many plants and animals cannot survive in water with high turbidity levels. High turbidity can be caused by soil erosion, waste discharge, excessive algal growth, storm water run-off, etc.

Turbidity is measured in Nephelometric Turbidity Units (NTU). The turbidity of surface water is usually between 1 NTU and 50 NTU. The standard for drinking water is 0.5 NTU to 1.0 NTU.

NTU	Turbidity level	Condition
<20	Low	Healthy level for aquatic animals and plants
20 - 50	Medium	Possible pollution problems
>50	High	Plants and animals may die if these levels persist

Stream Flow Rates:

Stream flow rate is the volume of water that moves over a fixed period of time. It is often expressed as cubic metre per second (m^3/sec). The velocity of water moving in the stream determines the amount of silt and sediment carried by the stream. In slow moving streams, sediments settle on the bed and affect the plant growth. Pollutants discharged have less effect on large swiftly flowing rivers than on small slow streams as slow flowing stream has less capacity to degrade and dilute wastes. The fast moving streams generally have high levels of dissolved oxygen. The conditions that determine the flow rate (velocity) of a stream are depth and slope of stream, type of stream bed, rainfall, withdrawals and discharge of water, and discharge of wastes and pollutants.

Stream flow rate is calculated by taking ratio of the distance travelled (in metre) to the time taken (in second). The result is then multiplied by a correction factor of:

- 0.9 if the waterway has a sandy or muddy bottom
- 0.8 if the waterway has a gravel or rock bottom

Dissolved Oxygen (DO)

Water can easily dissolve oxygen which is vital for aquatic organisms. The Oxygen from the atmosphere is dissolved quickly during the movement of waves, ripples and turbulence, and oxygen released from photosynthesis by aquatic plants . Algae also produce oxygen in water. Dissolved oxygen (DO) is a measure of the concentration of oxygen dissolved in the water. The value of DO can range from 0-18 parts per million (ppm). Water bodies with a DO level of 8 ppm is considered healthy, capable of supporting a large variety of aquatic organisms. Low DO levels have can drastic effects on sensitive macroinvertebrates species. On the other hand, a very high DO (super saturation) is harmful for organisms like fish.

Dissolved oxygen concentrations are affected by many factors such as water temperature, salinity, depth of water, presence of nutrients and chemicals in the water and vegetation. Generally, higher DO in water is resulted when:

- salinity of water is low.
- presence of ripples and waves in water that results in more contact with atmosphere.
- presence of rich aquatic plant life.
- dissolved minerals and wastes is low.
- temperature is low.
- Biochemical Oxygen demand (BOD) is high.

The acceptable level of DO needed by aquatic organisms is as follows:

DO Level	Conditions
2.0 ppm	Fish can live for short periods
<3.0 ppm	Few fish can survive for extended periods
<5.0 ppm	Fish grow and develop slowly
6.0 ppm	Healthful for most fish

The DO is calculated as given below:

$$\text{Dissolved Oxygen} = \frac{\text{Volume of titrant} \times 0.2 \times 1000}{\text{Volume of sample taken}}$$

(Since 1 mL of 0.025N $Na_2S_2O_3$ = 0.2 mg of O_2)

For example: If

Volume of Sodium thiosulphate V1 = 6.8 mL

Normality of Sodium thiosulphate N1 = 0.025 N

Volume of Sample V2 = 200 mL

Then, DO (mg/L)= 6.8 mg/L or 6.8 ppm

When a 200 mL sample is used, 1 mL of sodium thiosulphate solution (0.025 M) is equivalent to 1 mg/L dissolved oxygen in the sample.

(If 6.8 mL of sodium thiosulphate was used, then the DO of the sample is 6.8 mg/L)

Biochemical oxygen demand (BOD)

The health of the stream can also be determined by testing BOD. It is a measure of the amount of oxygen consumed by microorganisms and chemical processes in stream water during the specified period. A high value of BOD indicates higher rates of depletion of oxygen in stream water. This means less oxygen is available for aquatic life. The effects of high BOD are similar to that of low DO, thereby, measurement and value of BOD also indicates whether aquatic life is stressed or organisms die. The value of BOD is calculated by finding the difference in DO levels of initial sample and DO level of incubated sample.

The rate of oxygen consumption in a stream is affected by a number of factors such as temperature, pH, the presence of certain kinds of microorganisms, and the type and amount of decomposition and oxidation of organic and inorganic material in the water. Therefore, high BOD indicates pollution of stream.

The conditions of stream signified by level of BOD is as follows:

BOD Level	Conditions
1-2 ppm	Very clean water, presence of very little decay matter
3-5 ppm	Moderate clean water, presence of some decay plant matter
6-9 ppm	Unhealthy water, presence of high organic decay like algae bloom
10+ ppm	Harmful water, presence of unhealthy levels of organic decay like sewage.

Nitrates:

Nitrates are essential plant nutrients that are found in stream water. However, high levels can cause significant water quality problems like acceleration of eutrophication leading to excessive plant growth. This in turn affects dissolved oxygen, temperature, and other indicators making the water toxic for other aquatic life.

Nitrates dissolve readily in water. Nitrates and its compounds like ammonia generally end up easily water from sewage discharge, runoff from farms, agricultural fields and industrial discharges include sewage, runoff from fertilised lawns and parkland, run-off from agricultural land, and industrial discharges. Ammonia can also find its way into water courses from mis-connected properties where, for example, plumbing for washing machines is incorrectly connected to surface water drains that discharge into nearby rivers, streams and canals.

The quality of water against nitrate level is given below:

Freshwater Nitrate level	Quality indication of stream
< 1.0 ppm	High
1.0 – 1.8 ppm	Fair
1.8 – 2.8 ppm	Fair to poor
> 2.8 ppm	Poor

Procedure:

Step 1. Prepare for the field work

i. Know all about tests to be carried out for water quality before the field trip.

ii. Take copies of the handouts and observation sheets.

iii. Carry all the equipment required to collect sample and take measurements at stream side.

iv. Be thorough with safety rules and wear safety gears for the field work.

v. Determine the time of the survey.

Step 2. Select a local stream and the sites for the visit and pre-visit the sites to ensure that all the safety requirements are met for the study.

Step 3. Select the sampling locations such that you get valuable and reliable data. You may use sampling techniques suggested in Project Sample 6: Health Streams.

Step 4. Before the visit, test all the instrument and practise the following:

i. Measuring quantity of water

ii. Collecting water samples in bottles

iii. Using pipettes and burette

iv. Using thermometer

Step 5. Carry out the following tests. Some tests are to be completed in the field for accurate results. Bring the remaining samples of the water back to laboratory to complete the test.

I. *Testing for temperature (complete the test in the field)*

Materials: Thermometer, bucket, jug, sample bottles with cap, dry cloth napkin, measuring tape and Data Sheet.

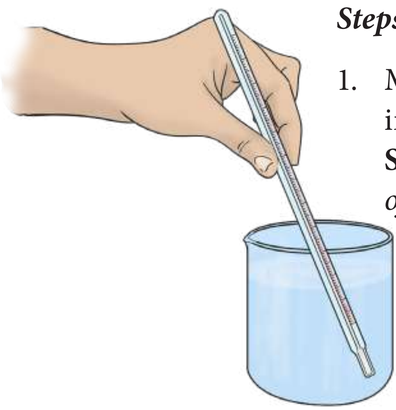


Figure 7.2. Measuring temperature

Steps:

1. Measure the air temperature by holding the thermometer in a shade for about two minutes and record in the **Stream Water Test: Data Sheet.** *(Do not touch the bulb of thermometer with your hand and do not let it touch any surface)*
2. Submerge the thermometer directly into the water in the stream (10 cm below the surface of water) or the container of the sample water for about two minutes and record the temperature.
3. Wash off the thermometer using distilled water and wipe it dry and place it safely into the kit.
4. Collect the sample water and bring it back to the laboratory for further tests. The samples of water can be collected by following the steps mentioned below:

(i). Rinse the bucket several times with stream water downstream of the sampling site.

(ii). Attempt to take the sample from the centre of the stream. (Half way between the sides and half way deep, upstream of your position) or take the sample from about 20 cm below the surface if the water is deep.

(iii). While collecting samples in a bottle (Fixing):

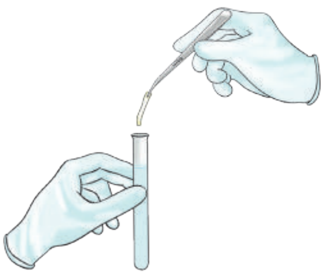
- Rinse the bottle with stream water.
- Lower the bottle gently into water sideways without creating bubbles. Turn it up still underwater and tap it gently with fingers to let any air bubbles present escape.
- Cap it and retrieve it. If you see any bubble, discard it and collect again.

Precaution!
Direct sunlight can affect samples, so store and perform all chemical tests in the shade.

II. Testing for pH (complete the test in the field)

Materials: test tube, dropper, universal indicator solution, pH colour chart and data sheet.

Steps:



1. Take 10 mL of sample water in a test tube.
2. Carefully add 5 drops of universal indicator solution to the water.
3. Gently shake the solution and observe the colour change.
4. Compare the colour using pH colour chart and record the pH of water in the data sheet.
5. Repeat and record the test two more times and find the average value of pH.

III. Test for turbidity (complete the test in the field)

Materials: Turbidity tube, bucket, jug and data sheet

Steps:

1. Take the sample of water in a bucket and stir it gently to have even distribution of suspended solids.
2. Using a jug, slowly pour small amount of water each time from the bucket into clean turbidity tube.

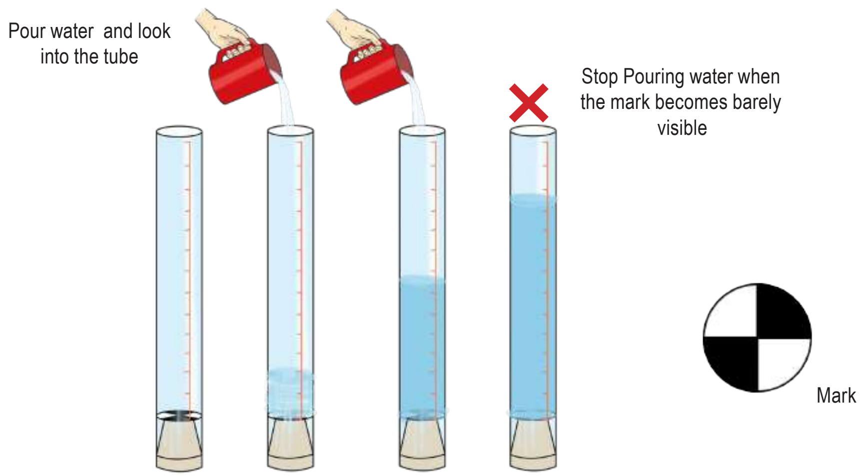


Figure 7.3. Measuring turbidity

3. Look down the tube and check whether the mark at the bottom of the tube is visible.
4. If visible, again pour small amount of water into the tube and look again. Repeat the process till the mark at the bottom of the tube becomes barely visible.
5. Note the readings on the tube in Nephelometric Turbidity Unit (NTU) on the data sheet (If exact reading cannot be estimated, take the range of the reading).

IV. Test for Dissolved Oxygen (DO)

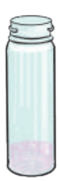
(Complete the test in the field if meter or probe is available)

Apparatus: Measuring cylinder, conical flask, BOD bottle of 200 mL, wash bottle, pipette, burette, burette stand and funnel.

Chemicals: Manganese sulphate, alkaline iodide azide, concentrated sulphuric acid, starch indicator, sodium thiosulphate (0.025N) and distilled water.

Steps (laboratory testing- Winkler Method):

1. The test for DO is done in two stages: Fixing the sample and Titrating the fixed sample. Fixing the sample is done by following steps:
   (i). Fill a three BOD water sampling bottles (200 mL) with stream water so that no air bubbles are trapped and cap it briefly. Do this on the sample collection site only.
   (ii). Remove the cap and carefully add 8 drops (2 mL) of Manganous Sulphate solution and 8 drops (2 mL) of Alkaline Potassium Azide using calibrated pipette just below the surface of each sample. A white precipitate called 'floc' will form.
   (iii). Cap the bottles and gently shake them about 30 seconds to mix the contents of bottles. Rest it for a few minutes for floc to settle (Complete this process slowly and do not rush as it affects the results).



(iv). Now remove the caps and carefully add 8 drops (2 mL) of sulphuric acid just above the surface of each sample.

(v). Cap the bottles and gently mix the solution by inverting the bottle repeatedly till precipitate vanishes.

(vi). The solution should appear yellow or yellowish brown. Precipitate might remain if the turbidity of water is high. If the solution is clear, it indicates total absence of oxygen or improper fixing. The sample will provide a valid result within 8 hours of fixing.

(vii). Label the bottles as Sample 1, Sample 2 and Sample 3.

2. Titration of fixed sample is carried out by following steps:

(i). Rinse the burette with sodium thiosulphate. Fix the burette to the stand and fill it with sodium thiosulphate.

(ii). Pour 203 mL of Sample 1 in a conical flask.

(iii). Start the titration immediately till the solution changes to a pale yellow colour.

(iv). Add two drops of starch indicator to the pale yellow solution and stir it slowly to mix. The solution turns into blue.

(v). Continue titration until the sample becomes colourless.

(vi). Note down the volume of sodium thiosulphate solution added to the sample in the data sheet and calculate the dissolved oxygen.

(vii). Repeat the process with the fixed Sample 2 and Sample 3, and record average DO accordingly in the data sheet.

V. Test for Biochemical Oxygen Demand (BOD) (Complete the test in the laboratory)

Apparatus: Measuring cylinder, conical flask, BOD bottle of 200 mL, wash bottle, pipette, burette, burette stand and funnel.

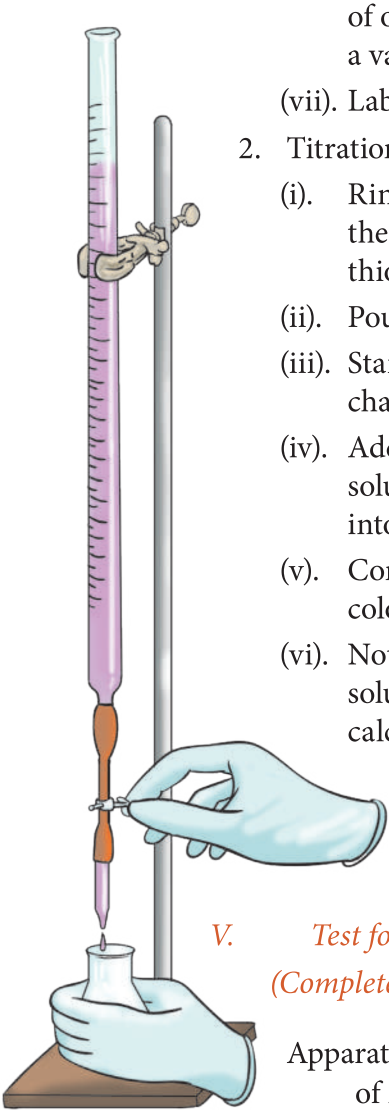


Figure 7.4. Titration

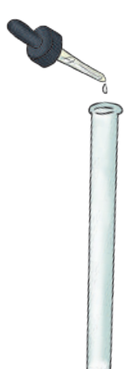
Chemicals: Manganese sulphate, alkaline iodide azide, concentrated sulphuric acid, starch indicator, sodium thiosulphate, and distilled water.

Steps (laboratory testing-Winkler Method):

1. The test for BOD is same as DO which is done on three stages: Fixing the sample, Titrating the fixed sample immediately and Titrating the fixed sample after incubation. Fixing the sample is done by following steps:
   (i). Fill six BOD water sampling bottles (200 mL) with stream water so that no air bubbles are trapped and cap it briefly. Do this on the sample collection site only.
   (ii). Remove the cap and carefully add 8 drops (2 mL) of Manganous Sulphate solution and 8 drops (2 mL) of Alkaline Potassium Azide using calibrated pipette just below the surface of each sample. A white precipitate called 'floc' will form.
   (iii). Cap the bottles and gently shake them about 30 seconds to mix the contents of bottles. Rest it for a few minutes for floc to settle. (Complete this process slowly and do not rush as it affects the results)
   (iv). Now remove the caps and carefully add 8 drops (2 mL) of sulphuric acid just above the surface of each sample.
   (v). Cap the bottles and gently mix the solution by inverting the bottle repeatedly till precipitate vanishes.
   (vi). The solution should appear yellow or yellowish brown. Precipitate might remain if the turbidity of water is high. If the solution is clear, it indicates total absence of oxygen or improper fixing. The sample will provide a valid result within 8 hours of fixing.
   (vii). Label the bottles as Sample 1, Sample 2, Sample 3, Sample 4, Sample 5 and Sample 6.

2. Titration of fixed sample is carried out by following steps:
   (i). Rinse the burette with sodium thiosulphate. Fix the burette to the stand and fill it with sodium thiosulphate.
   (ii). Pour 203 mL of Sample 1 in a conical flask.
   (iii). Start the titration immediately till the solution changes to a pale yellow colour.
   (iv). Add two drops of starch indicator to the pale yellow solution and stir it slowly to mix. The solution turns into blue.
   (v). Continue titration until the sample becomes colourless.
   (vi). Note down the volume of sodium thiosulphate solution added to the sample in the data sheet and calculate the dissolved oxygen.
   (vii). Repeat the process with the Sample 3 and Sample 4, and record the average DO accordingly in the data sheet.
   (viii).Store Sample 4, Sample 5 and Sample 6 in a dark room for 5 days at 20°C for incubation.
   (ix). After five days, carryout the DO test with the incubated Sample 4, Sample 5 and Sample 6, and find the average.
   (x). Calculate the BOD by finding the difference between the average DO content in sample before 5 days and average DO content in sample after 5 days.

VI. Test for Nitrates (complete the test in the field)



Materials: Water testing kit with mix acid reagent, Nitrate reducing agent containing Cadmium, test tubes, corks, measuring spoon, standard colour chart

Steps:

1. Take 2.5 mL of the sample water in a test tube.
2. Slowly add 2.5 mL mix acid reagent to the sample water in the test tube.

Precaution!
Nitrate reducing agent contains Cadmium, therefore dispose it properly.

3. Cap the test tube with cork and mix the solution gently for two minutes.
4. Measure 0.1 g of Nitrate Reducing Agent using measuring spoon and add it to the mixture in the test tube.
5. Cap the test tube again and invert it gently about every second for a minute.
6. Rest it for about 10 minutes.
7. Take the standard colour chart and match the colour of sample solution to one of the standards.
8. Record the readings in data sheet.

VII. Measuring stream flow rates-float method (complete the test in the field)

Materials: Object that float in water (fruits, ball, paper boat, etc), net, measuring tape (100 m), rope and stopwatch.

Steps:

1. Upstream of your sampling site, choose a section of waterway that is relatively straight and free of vegetation and obstacles.
2. Mark out a 10 m length of the waterway.
3. Position a person at start and end of the 10 m section. Place rope across the stream to make the start and end position.
4. Place the object that floats on the surface of water near the middle of the waterway at least 2 m upstream of the start position.
5. Release the object.
6. Start the stopwatch when the object strikes start line rope mark.
7. Stop the watch when the object gets to the end mark of the 10 m section.
8. Record the time in the data sheet and calculate the velocity. Repeat the procedure three times and find the average of the results.

Observation

Stream Water Test: Data Sheet

School: ____

Class: ______________________ Group name and number:___________________________

Name of the stream: ____

Village: _________________________ Dzongkhag: ________________________________

Date & Time of Test ____

Test Record

1. Type of stream (Rocky-bottom/Muddy-Bottom): ____________________________________

2. Temperature: ________________________

3. Stream flow rate a) 1st Test _______ m/s b) 2nd Test ________m/s c) 3rd Test __________m/s

   Average Stream flow rate (No flow / Slow / Medium / Fast): ___________________________

4. pH Test water sample:

   a) pH value -1st Test: _______, b) pH value -2nd Test: _______ c) pH value -3rd Test: ________

   Average value of pH = _____________________________

5. Turbidity (NTU) :________________________

6. Dissolved Oxygen (DO): Tabulate the result in the following Table 1.1 .

Table 1.1. DO observation sheet

Sample Number	Volume of Sample (mL)	Burette Reading (mL)		Volume of Titrant (mL) (Sodium Thiosulphate Solution used)	Dissolved Oxygen (mg/L or ppm)
		Initial	Final		
Sample 1					
Sample 2					
Sample 3					

Average DO level: ___________________________ mg/L

7. Biochemical Oxygen Demand (BOD). Tabulate the result in the following Table 1.2.

Table 1.2. BOD observation sheet

Sample Number	Volume of Sample (mL)	Burette Reading (mL)		Volume of Titrant (mL) (Sodium Thiosulphate Solution used)	Dissolved Oxygen (mg/L or ppm)
		Initial	Final		
Sample 1					
Sample 2					
Sample 3					
Average DO level (Initial samples)=					
Sample 4					
Sample 5					
Sample 6					
Average DO level (Incubated samples)=					
BOD =					

8. Nitrate Level: ________________ ppm

Result

1. The stream flow rate is ……………………
2. The average temperature of the sample water from the stream is = ………………… ^{o}C.
3. The average pH of the sample water from the stream = ……………………….
4. The turbidity (NTU) of the sample water from the stream = ……………………….
5. The level of nitrate of the sample water from the stream = ………………………. ppm.
6. The dissolve oxygen (DO) level in water from the stream = ………………………. mg/L or ppm.
7. The Biochemical Oxygen Demand (BOD) level in water from the stream = ……… mg/L or ppm.

Conclusion

The analysis of water quality test indicates that the temperature of stream water is ……………. (above/below) 20°C. High temperature of water is generally unfit for fishes to survive. At …………….°C, it is indicative that ……… (lot/very less/ no) fishes can survive. This temperature also indicates that the level of DO in water is ……………… (low/moderate/high). The stream water is ………….. (stagnant / slow / medium / fast) infer that the water is ……….. (better/not much) aerated and thereby contains ………(less/more) dissolved oxygen. It also suggests that pollutants have ……..(great/less) impact on the stream. The turbity of water (NTU) is ……………… (high/low) which …………………. (allows/ blocks) sunlight reaching the bottom of the stream, therefore making conditions ……………………. (favourable/ unfavourable) for submerged aquatic plants.

The pH value of water suggests that the water is …………. (acidic/neutral/ alkaline), which indicates …………(no/slight/high) pollution of the water. In this water, most fishes and aquatic invertebrates ………….. (can/cannot) survive. The nitrate level indicates that the water is ………… (safe/unsafe) for drinking. This explains the ……………. (no/elevated) bloom of algae ……….. (depleting/ not depleting) the DO in water. The DO level of water is found to be ………. (saturated/ anoxic/ moderate). Here the fishes, aquatic plants and other organisms……………… (can/ cannot) thrive. The BOD of water is ……………. ppm, that shows water is ………………….. (very clean/ moderately clean/unhealthy/ harmful) for all aquatic life. BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those of low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

In general, the quality of stream water is ………………. (poor and unsafe/ less polluted/ clean and safe). However, more tests at different seasons must be carried out for the accuracy of the results. The other tests for phosphorous, fluoride, chlorine and E.coli must be carried out to determine the fitness of water for drinking.

Safety!

- Always wear protective clothing.
- Wash off any reagent spills or drips onto the skin immediately.
- Treat all chemicals as if they are dangerous.

Tips to draw conclusions

Summarise how your results from your data analysis support or contradict your original hypothesis. The conclusion should:

- *summarise your science project results in a few sentences and use this summary to support your conclusion. Include key facts from your background research to help explain your results as needed.*
- *state whether your results support or contradict your hypothesis. Remember that it is not important for the hypothesis to be correct. It is important, however, that you explain why you got the results.*
- *if appropriate, state the relationship between the independent and the dependent variable.*
- *summarise and evaluate your experimental procedure, making comments about its success and effectiveness.*
- *identify and critique procedural mistakes that could have affected the data.*
- *suggest changes in the experimental procedure (or design) and/or possibilities for further study.*

1. Making your own first aid box

First Aid Box

Any standard first aid kit should contain minimum of following items:

- Telephone numbers of emergency personnel (police, ambulance, fire)
- A first aid manual
- Band-aids for minor cuts (5-10 strips)
- Antibacterial or alcohol wipes (3 nos)
- First aid ointment
- Gauze pads (3x4 inches) for deep wounds bleeding (3 nos).
- Pain killer
- A needle for removing splinters
- A single-edged razor blade
- Gauze bandage (width 2-inch) for large cuts (2 rolls)
- Compress bandage to hold dressings in place (2 nos)
- A 3-inch wide elastic bandage for sprains and applying pressure to bleeding wounds

2. Turbidity tube making

Materials:

- Black Permanent Marker
- A 20 cm long clear tube
- Rubber Bands
- Rubber Stopper
- Scrap Paper or Newspaper
- Scissors
- Super-Glue
- Measuring tape
- Plastic Jug (Opaque and throw-away)

Procedure:

Step 1. Measure the diameter of the clear tube.

Step 2. Cut a circle out of a flat side of the jug such that circle is 1 cm longer than the tube's diameter.

Step 3. Colour the disc with checkered pattern using the black permanent marker to make the viewing disk.

Step 4. Take rubber stopper and apply a thin line of super-glue on its rim of the rubber stopper.

Step 5. Quickly paste the rubber stopper on the back of the viewing disk.

CAUTION: Super-glue binds skin instantly.

Step 6. Insert the rubber stopper into the bottom of the clear tube.

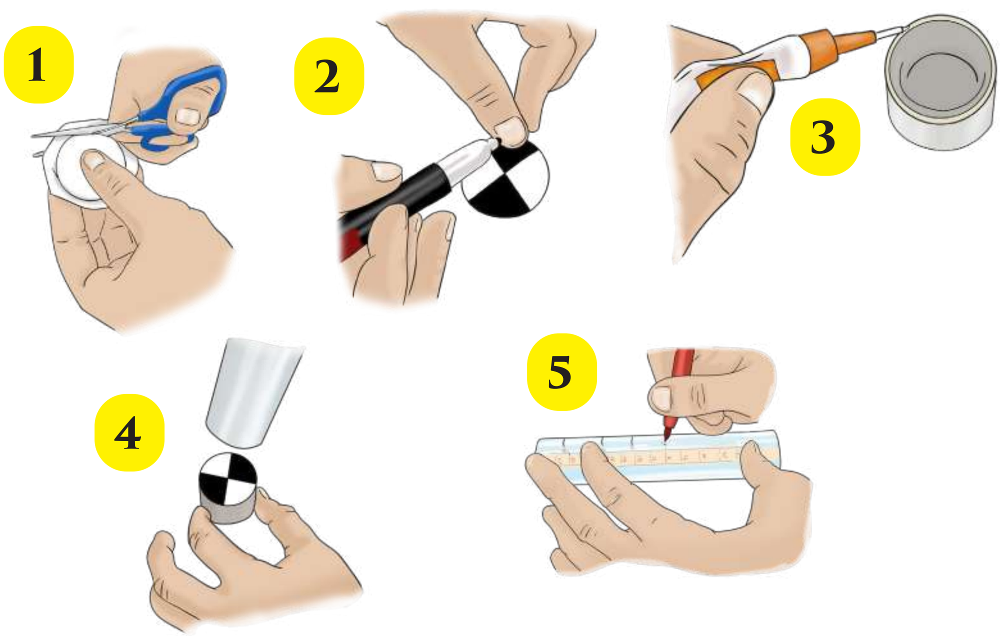


Figure 8.1. Making turbidity tube

Step 7. Attach the tape measure to the tube using rubber bands at both ends. Align the zero-end of the tape measure with the viewing disk so that measurements increase as you move up the tube.

Step 8. Mark and write the corresponding turbidity level all the way up the tube using the conversion table given below:

Table 1.3. Length-to-Turbidity Conversion

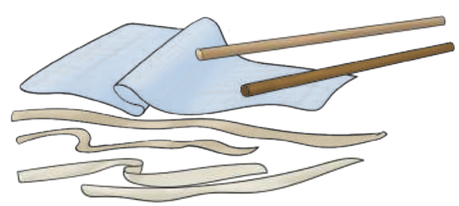
Centimeters	NTU
6.7	240
7.3	200
8.9	150
11.5	100
17.9	50
20.4	40
25.5	30
33.1	21
35.6	19
38.2	17
40.7	15
43.3	14
45.8	13
48.3	12
50.9	11
53.4	10
85.4	5

3. Net making

(i). Kick-nets

Materials

- 1.2 m x 1.5 m nylon net, or mosquito net
- Four 6 cm x 150 cm strips of heavy cloth
- Two wooden handle, 1.5 m each
- Needle and thread or heavy staples and staple gun



Procedure:

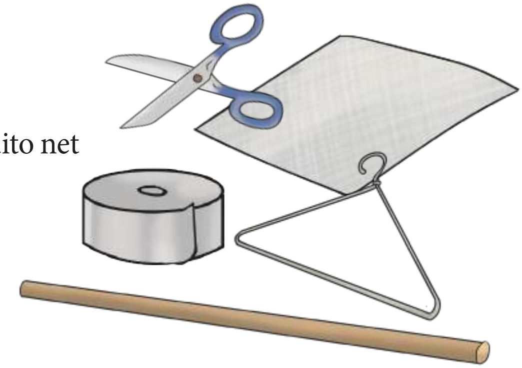
Step 1. Take nylon net and stitch the heavy cloth strips around its edges.

Step 2. Fold the two short edges and stitch them to make casing for the wooden stick.

Step 3. Insert the wooden sticks into the casing and secure with heavy staple pins. The final size of the net must be at least 1 m x 1.2 m.

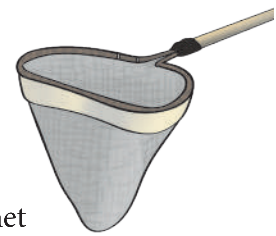
(ii) D- Frame Net

Materials



- 90 cm strips of heavy cloth
- 30 cm x 30 cm nylon net, or mosquito net
- Needle and thread
- Scissors
- Wire coat hanger
- 1 m long wooden handle
- Duct tape
- Wire and pliers

Procedure:



Step 1. Cut the rectangular net along its diagonal to get four triangular pieces. Take three triangular nets and sew them together such that it forms a net in shape of a prism.

Step 2. Stitch the heavy cloth strips along the mouth of the net and make a casing for the wire.

Step 3. Untwist the wire coat hanger, slip it into the net casing, and re-twist it such that prism shape of the net is maintained.

Step 4. Straighten the hook of the hanger and fix it to the wooden handle using a duct tape.

Step 5. With the help of pliers cut a length of wire and wind it around the handle over the duct tape to securely fix the net to the wooden handle.

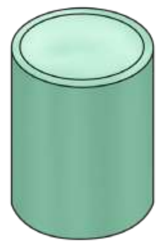
Note: The frame of the net can be made in various shapes too.

Figure 8.2. Net of various shapes

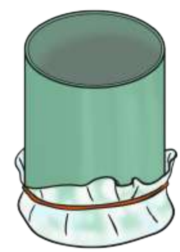
4. Making an underwater viewer

Catching animals for study and observation involves risk and at the same time they might be injured in the process of collection and observation. Using the underwater viewer, you can explore and discover much about organisms under water without catching any animals.

Material:



- Plastic bucket
- Scissor
- Transparent plastic sheet
- Rubber band
- Sharp knife or jig saw



Procedure:

Step 1. Carefully cut out the bottom of the bucket using jig saw or blade leaving 3 cm from the rim. (Take help from adult)

Step 2. Clean the sharp edges to get smooth cut.

Step 3. Place the transparent plastic over the cut area.

Step 4. Put the rubber band around the plastic to fix and seal it to the bucket.

Step 5. Make sure the water does not leak into the bucket.

Step 6. Immerse the plastic side (bottom of bucket) just below the surface of the water. Peer down through the mouth of the bucket.

5. Preserving bug samples

Materials:

- Glass vials with screw caps
- Ethyl alcohol
- Glycerin
- Dropper
- Small funnel

- Adhesive labels
- Permanent marker
- Paper and Pencil
- Forceps

Procedure:

Step 1. Fill two-thirds of the vial with alcohol.

Step 2. Using forceps, place the specimen into vial.

Step 3. Add several drops of glycerin using an eyedropper to keep your specimen from becoming brittle (2 to 3 drops for small vials and 4 to 5 drops for medium vials).

Step 4. Cap the vials and label specimen jar using permanent marker and adhesive labels.

6. Making Mud scoop

Materials:

- Plastic jerry cans (thrown-way) or small plastic drum with cap
- Scissors
- Sharp knife

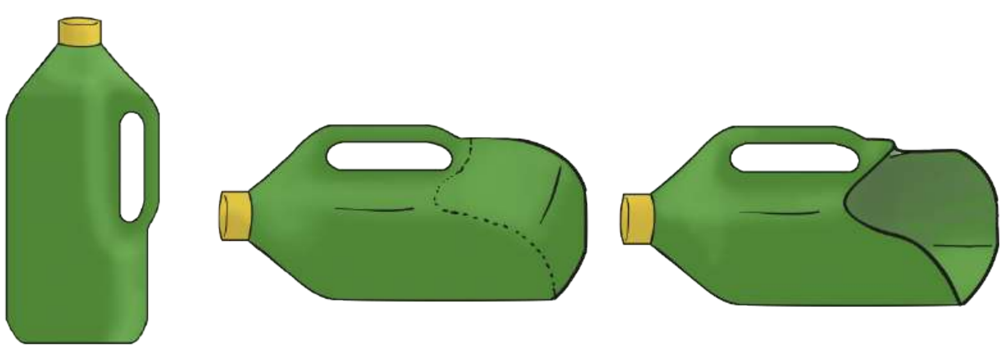
Procedure:

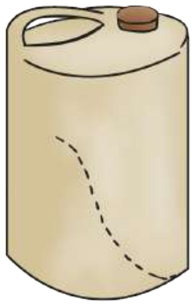
Step 1. Remove all the labels from the jerry can.

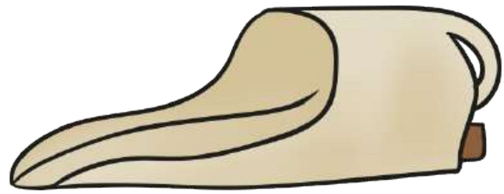
Step 2. Mark out the area at the bottom to be cut away from the plastic jerry can.

Step 3. Carefully cut along the line.

Step 4. Leave the cap on tightly screwed.



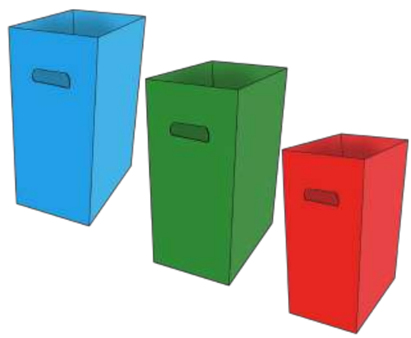




7. Making waste bins

Materials:

- Big cartoon boxes (thick cardboard)
- Scissors
- Ruler
- Pencil
- Cutter
- Markers
- Duct tape
- Plastic sheet



Procedure:

Step 1. Take three big cartoon boxes.

Step 2. Leave the fold leaves on upper side of all the boxes.

Step 3. Paste duct tape on the edges of the box to make it firm.

Step 4. Paste duct tape on the bottom of the box. Make sure it is strong enough to hold the waste.

Step 5. Measure and cut the plastic sheet of the size of the all the inner faces of the box.

Step 6. Paste the cut plastic sheets on inner walls of the boxes.

Step 7. Colour the boxes into green, blue and red.

Step 8. Make three labels: Dry Waste, Wet Waste and Hazardous Waste using markers and paper.

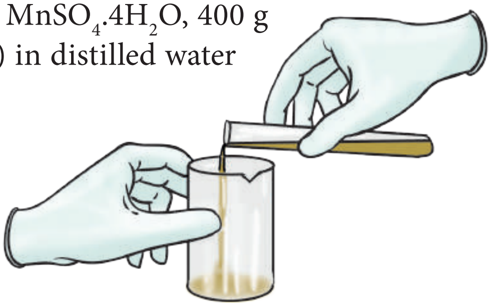
Step 9. Paste Dry Waste label on the blue box. Wet Waste label on the green box and Hazardous Wastes on the red box.

8. Preparation of Reagents

For testing the given sample, prepare the following reagents.

Procedure

1. Manganese sulphate solution
2. Dissolve manganese sulphate (480 g $MnSO_4.4H_2O$, 400 g $MnSO_4.2H_2O$ or 364 g $MnSO_4.H_2O$) in distilled water that is freshly boiled and cooled.
   - Filter the solution.
   - Make 1000 mL (one litre) manganese sulphate solution.



3. Alkaline Iodide Sodium Azide solution
   - Add 150 g of potassium iodide to 700 g of Potassium hydroxide.
   - Dissolve it in water that is freshly boiled and cooled and make 1000 mL (one litre) alkaline iodide solution.
   - Dissolve 10 g of Sodium Azide (NaN_3) in 40 mL of distilled water and add this with constant stirring to the cool alkaline iodide solution prepared.

(If potassium compounds are not available, use 500 g of sodium hydroxide with 135 g of sodium iodide)

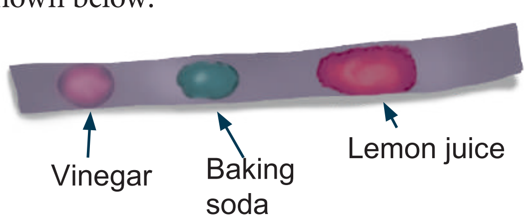
4. Sodium Thiosulphate stock solution
   - Weigh approximately 25 g of sodium thiosulphate.
   - Dissolve it in boiled distilled water and make 1000 mL of the solution.
   - Add 1 g of sodium hydroxide to preserve it.
5. Starch indicator
   - Weigh 2 g of starch and dissolve in 100 mL of hot distilled water.
   - Add 0.2 g of salicylic acid as preservative to preserve the starch indicator.

9. Making pH Indicator solution

1. Using beetroot
   - Clean the beetroot and wash them properly.
   - Chop the beetroot into small pieces.
   - Put them in a container and boil them in water for 30 to 60 minutes.
   - Let it cool down.
   - Mash the beetroot and separate the juice using a sieve.
   - The juice acts as a natural pH indicator.
2. Using purple cabbage:
   - Chop the purple cabbage into small pieces and put them in a container.
   - Boil it in water for 30 to 60 minutes.
   - Let it cool down and separate the juice using a sieve.
   - The juice acts as a natural pH indicator.

10. Making pH Indicator strips

- Take strips of filter paper.
- Dip strips of filter paper into the purple cabbage or the beetroot indicator solution and leave to dry.
- Drop the solutions to test onto the paper and watch as the colour changes to find out whether a solution is acidic or alkaline.
- If the solution is alkaline, the paper turns blue and if the solution is acidic, the paper turns red. The colour change of pH indicator strip when vinegar (acid), lemon juice (acid) and baking soda (alkaline) is shown below:



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