

CENTRAL BOARD OF SECONDARY EDUCATION (CBSE)

Kaushal Bodh • Skill Education & Vocational Learning (Class VIII)

COMPREHENSIVE ACADEMIC & EXPERIMENTAL PROJECT REPORT

HYDROPONICS

The Science of Soil-less Farming & Sustainable Modern Agriculture

Project Overview: An in-depth exploratory manual and notes covering definition, scientific principles, system classifications, nutrient dynamics, advantages, disadvantages, practical DIY project execution, and future scope in urban food security.

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Department: Science / Skill Education
Academic Session: 2026 – 2027
Submission Date: _____

STUDENT DECLARATION

I hereby declare that the project work entitled "**Hydroponics: Soil-less Farming**" submitted for the Class VIII *Kaushal Bodh* assessment is an authentic record of practical and theoretical work completed by me under the guidance of my teacher. All assistance received and resources referenced have been duly acknowledged.

Date: _____

Student Signature: _____

BONAFIDE CERTIFICATE

This is to certify that Master/Miss _____ of Class VIII, Roll No. _____ has successfully completed the vocational project titled "**Hydroponics**" prescribed by the CBSE under the *Kaushal Bodh* skill development framework for the academic year 2026–2027.

Teacher-in-Charge Signature

Head of Institution / Seal

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I also extend my sincere thanks to my parents and classmates for their immense support during the setup and monitoring of my classroom experimental model.

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CHAPTER 1: INTRODUCTION & CORE CONCEPTS

1.1 What is Hydroponics?

Hydroponics is a modern agricultural methodology of cultivating plants in an aqueous, nutrient-enriched solution without the use of traditional soil. Plants are supported using inert physical substrates (such as coco peat, perlite, or clay pebbles) while their root systems are directly bathed in or supplied with dissolved essential minerals.

Etymological Origin

The term **Hydroponics** originates from two Greek words:

- *Hydro* = Water
- *Ponos* = Labor or Work

Literal Translation: "Working with Water".

1.2 Historical Evolution

While hydroponics seems modern, its principles date back centuries:

- **Hanging Gardens of Babylon (c. 600 BCE):** Ancient precursor utilizing water fed through elevated channels.
- **Aztec Chinampas (10th Century):** Floating gardens built on shallow lake beds.
- **Julius von Sachs & Wilhelm Knop (1859-1865):** German botanists who demonstrated that plants could grow in liquid solution containing only known inorganic elements.
- **Dr. William Frederick Gericke (1929):** Coined the term "Hydroponics" at the University of California and demonstrated commercial tomato plants growing to extraordinary heights in water tanks.

1.3 What Do Plants Really Need from Soil?

To understand hydroponics, we must ask: *Do plants strictly need soil?* Biological studies prove soil is merely a physical holder and reservoir. Plants require four fundamental elements to thrive:

FOUR ESSENTIAL PLANT REQUIREMENT PILLARS

1. Physical Support (Anchorage)	2. Water (H ₂ O for transpiration)
3. Dissolved Oxygen (Root cellular respiration)	4. Mineral Nutrients (N, P, K, Ca, Mg, Micro)

In conventional soil farming, roots must expend metabolic energy expanding through dense soil to seek water and ions. In hydroponics, water, oxygen, and nutrients are delivered directly to the root tips. Consequently, energy is redirected toward leaf, flower, and fruit growth.

CHAPTER 2: ESSENTIAL TERMINOLOGY

Mastering hydroponics requires familiarity with key scientific terms used in horticulture and environmental science:

Term	Definition & Practical Significance
Nutrient Solution	A balanced mixture of water and dissolved inorganic chemical salts providing essential macro and micro elements required for plant photosynthesis and cellular growth.
Inert Growing Medium	A non-soil substrate (e.g., Coco peat, LECA, Perlite) that holds roots and provides physical stability without altering the chemical balance or nutritional value of the liquid.
pH (Potential of Hydrogen)	A logarithmic scale (0–14) measuring hydrogen ion concentration. Hydroponics targets a slightly acidic range of $5.5 \leq pH \leq 6.5$ for optimal ion absorption.
EC (Electrical Conductivity)	Measured in deciSiemens per meter (dS/m) or microSiemens/cm. EC measures the concentration of total dissolved ionic salts in the solution.
TDS / PPM	Total Dissolved Solids expressed in Parts Per Million . Direct indication of nutrient density ($1 \text{ dS/m} \approx 500 \text{ PPM}$ depending on scale).
Dissolved Oxygen (DO)	The amount of gaseous oxygen dissolved in water. Critical for plant root respiration to prevent pathogen infestation and root rot.
Reservoir	The holding tank or container where the nutrient solution is mixed, monitored, and stored before circulation.

CHAPTER 3: SOIL vs. HYDROPONIC FARMING

A rigorous scientific comparison between traditional soil-based agriculture and modern hydroponic cultivation highlights key differences:

Parameter	Traditional Soil Farming	Hydroponic Cultivation
Water Usage	High consumption. Large volumes are lost to deep percolation, evaporation, and weed absorption.	Extremely efficient. Recirculating systems consume 80%–90% less water .
Land Requirement	Vast horizontal field area required; limited by soil fertility.	Minimal footprint; enables vertical stacking in urban areas.
Growth Rate	Slower. Roots spend energy growing through dense soil looking for nutrients.	30%–50% faster growth due to direct availability of nutrients at root tips.
Pests & Weeds	High incidence of soil-borne fungi, nematodes, and weeds; requires chemical pesticides.	Zero soil weeds; minimal soil-borne pathogens; drastic reduction in pesticide dependency.
Control Over Nutrients	Difficult to measure or control exact soil nutrient levels across field zones.	Complete micro-level control over pH, EC, and exact nutrient formulas.
Labor Intensity	High manual labor (tilling, weeding, furrowing, soil preparation).	Automated operations; physical labor reduced once system is built.

CHAPTER 4: ADVANTAGES & DISADVANTAGES

4.1 Detailed Advantages

- 1. Superior Water Conservation:** In closed-loop systems, water is continuously recycled. Only water transpired by the plant leaves or evaporated is replaced.
- 2. Maximum Land Yield:** Hydroponics allows crops to be grown vertically in multi-tier racks. A 10-story indoor farm can produce up to 50 times more yield per square meter than traditional fields.
- 3. Climate-Independent Production:** Indoor setups with light-emitting diodes (LEDs) and climate controls produce food 365 days a year regardless of outside weather, frost, or drought.
- 4. Clean and Safe Yield:** Eliminates mud splash and root contamination, producing pristine leafy greens ready for consumption.

4.2 Disadvantages & Limitations

Key Challenges & Operational Risks

- **High Initial Setup Costs:** Pumps, timers, grow lights, EC/pH meters, and specialized channels require capital investment.
- **Vulnerability to Power Outages:** Active systems rely on continuous electricity. If pumps stop running in an NFT system, roots can dry out and die within hours.
- **Rapid Pathogen Spread:** If a waterborne fungus like *Pythium* (Root Rot) enters the reservoir, it recirculates quickly to all connected plants.
- **Requirement of Technical Knowledge:** Requires basic chemistry understanding to monitor pH, EC, and plant deficiency symptoms accurately.

CHAPTER 5: CLASSIFICATION OF HYDROPONIC SYSTEMS

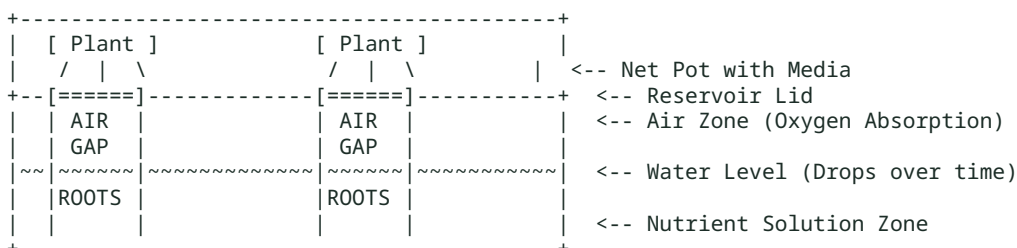
Hydroponic systems are broadly classified into two primary categories based on operation: **Passive Systems** (no moving mechanical parts) and **Active Systems** (utilizing pumps, timers, and aerators).

5.1 Passive Hydroponic Systems

1. The Kratky Method

Invented by Dr. Bernard Kratky at the University of Hawaii, this is a non-circulating passive technique ideal for beginners and school science projects.

CROSS-SECTION: THE KRATKY SYSTEM



- **Mechanism:** Plants are set in net pots suspended above a tank of nutrient solution. As the plant absorbs water, the fluid level lowers, leaving an expanding air space.
- **Oxygen Supply:** The upper roots adapt as "air roots" to absorb atmospheric oxygen, while lower roots absorb water and nutrients. No air pump is needed.
- **Best Crops:** Fast-growing leafy greens (lettuce, spinach, basil, coriander).

2. The Wick System

- **Mechanism:** Capillary action draws liquid solution from a lower reservoir into an upper grow tray through an absorbent fabric wick (e.g., cotton or nylon line).
- **Limitation:** Unsuitable for large plants with high water consumption rates.

5.2 Active Hydroponic Systems

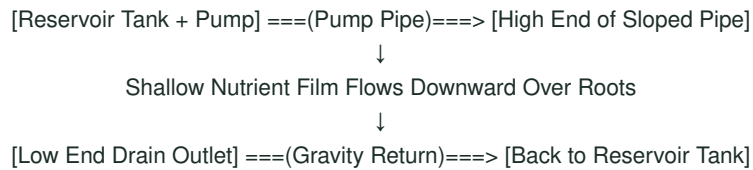
1. Deep Water Culture (DWC)

Plants are suspended in foam rafts floating directly on a deep reservoir of oxygenated nutrient water. An electric **air pump connected to an air stone** continuously bubbles air into the liquid to prevent root suffocation.

2. Nutrient Film Technique (NFT)

Nutrient solution is pumped from a main reservoir into long, slightly sloped PVC channels. The fluid flows as a very shallow stream ("film") over the tips of the bare root mat before draining back into the reservoir via gravity.

NFT SLOPED FLOW SCHEMATIC



3. Ebb and Flow (Flood & Drain)

A grow bed filled with clay pebbles is periodically flooded with nutrient solution using a submersible pump on a timer. Once filled to a set height, a bell siphon or timer shuts off the pump, draining the bed back into the tank. This cycle forces fresh oxygen into the root zone.

4. Aeroponics

Roots hang suspended in an enclosed air chamber where high-pressure mist nozzles spray them with fine nutrient droplets every few minutes. Aeroponics offers the highest oxygenation level of any system.

CHAPTER 6: GROWING SUBSTRATES (MEDIA)

In soil-less agriculture, substrates physically support plant stems and retain moisture and air pockets around roots. Substrates must be **inert**—meaning they will not breakdown, leach toxic elements, or alter the solution pH.

Medium	Source / Composition	Key Properties	Best Application
Coco Peat (Cair)	Processed natural husks of coconuts.	Excellent water retention, organic, eco-friendly, biodegradable.	Kratky systems, microgreens, seed germination.
LECA (Clay Pebbles)	Expanded clay fired in high-temperature kilns.	Highly porous, excellent aeration, re-usable after cleaning.	Ebb & Flow, DWC, Net pot support.
Perlite	Mined volcanic glass expanded by high heat.	Extremely lightweight, improves aeration, bright white color.	Blended with Coco peat to prevent compaction.
Rockwool	Spun molten basalt rock fibers.	High moisture retention, uniform fiber density.	Commercial seed germination cubes.

CHAPTER 7: PLANT NUTRITION & SOLUTION MANAGEMENT

7.1 Chemical Essentials for Growth

Plants require 16 inorganic chemical elements divided into two major groups based on quantities consumed:

1. Primary & Secondary Macronutrients

• Primary (N-P-K):

- **Nitrogen (N):** Leaf and vegetative stem development.
- **Phosphorus (P):** Root expansion, flower initiation, and energy transfer (ATP).
- **Potassium (K):** Enzyme activation, disease resistance, and fruit formation.

- **Secondary:** Calcium (Ca) for cell wall structural integrity, Magnesium (Mg) for chlorophyll production, and Sulfur (S).

2. Essential Micronutrients (Trace Elements)

Required in minute concentrations: Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl).

7.2 Managing pH (Acidity / Alkalinity)

The solution pH governs nutrient availability. If the pH drops below 5.0 or rises above 7.0, specific ions become chemically bound and locked out from root uptake.

OPTIMAL HYDROPONIC PH RANGE

[4.0 Too Acidic] <----- [5.5 — 6.5 OPTIMAL ZONE] -----> [7.5 Too Alkaline]

*Use mild Phosphoric Acid ("pH Down") or Potassium Hydroxide ("pH Up") to make micro adjustments.

CHAPTER 8: DIY CLASSROOM PROJECT GUIDE

This hands-on practical project is tailored for Class 8 *Kaushal Bodh* vocational skill portfolios using accessible, low-cost materials.

Project Activity: Constructing a 2-Litre Bottle Kratky Hydroponic Setup

Required Materials

- Clean 2-Litre plastic soda bottle
- Utility cutter/scissors and ruler
- Coco peat or clay pebbles (washed)
- Hydroponic Twin-Pack Liquid Nutrients (Formula A & Formula B)
- Black chart paper or opaque tape
- Healthy seedling (e.g., Mint, Basil, or Lettuce)

Step-by-Step Execution Protocol

Step 1: Container Construction

Using scissors, carefully cut the top 1/3 section of the plastic bottle off. Invert this top cone section—it will act as a funnel holding the plant media. Place it inside the lower bottle reservoir.

Step 2: Algae Prevention (Blackout)

Wrap black chart paper or opaque duct tape completely around the exterior of the bottom base reservoir.

Scientific Reason: Nutrient water exposed to light will rapidly develop green algae, which competes with plant roots for oxygen and nutrients.

Step 3: Solution Preparation

Fill the lower reservoir with 1 Litre of clean water. Add equal recommended drops of Hydroponic Formula A and Formula B. Stir thoroughly until fully dissolved.

Step 4: Planting & Assembly

Thread a cotton wick through the bottle cap hole (or line the funnel with mesh). Fill the inverted top section with wet coco peat or clay pebbles. Plant your seedling gently, ensuring the lower roots reach down toward the water solution line.

CHAPTER 9: ROLE IN MODERN SOCIETY & FUTURE OUTLOOK

9.1 Urban Food Security & Vertical Farming

With global urbanization expanding rapidly, prime agricultural land is shrinking. Vertical hydroponic farms inside multi-story facilities allow cities like Singapore, Tokyo, and New Delhi to produce fresh vegetables locally, reducing transportation costs and carbon emissions.

9.2 Climate Resilience

Hydroponics provides predictable year-round crop yields protected from unpredictable climate change events like extreme droughts, unseasonal rainfall, floods, and severe heatwaves.

9.3 Space Exploration (NASA & ISRO)

Space agencies are developing advanced hydroponic and aeroponic growth chambers for long-duration space travel. Growing crops aboard the International Space Station (ISS) and proposed future lunar/Martian bases provides astronauts with fresh nutrition and psychological benefits.

CHAPTER 10: ASSESSMENT QUESTIONS & PROJECT LOG SHEET

10.1 Multiple Choice Questions (MCQs)

- The word *Hydroponics* translates literally to:
a) Water Earth b) Working with Water c) Air Growth d) Liquid Soil
- Which of the following hydroponic systems requires NO electricity or air pump?
a) Deep Water Culture b) NFT c) Kratky Method d) Aeroponics
- What is the optimal pH range for most hydroponic plants?
a) 3.0 to 4.0 b) 5.5 to 6.5 c) 7.5 to 8.5 d) 9.0 to 10.0
- Why is the water reservoir in a hydroponic system wrapped in opaque paper or dark tape?
a) Keep water warm b) Prevent algae growth c) Look attractive d) Stop water evaporation

10.2 Short & Long Answer Questions

- Define hydroponics. Mention two major macronutrients essential for leafy plant growth.
- Explain why hydroponic farming consumes significantly less water than traditional soil farming.
- Differentiate between an *Active* and a *Passive* hydroponic system with suitable examples.
- Describe two main disadvantages of hydroponics and how modern technology attempts to overcome them.

10.3 Classroom Experimental Observation Log Sheet

Students should maintain this observation table for 4 weeks during their project execution:

Week	Plant Height (cm)	Leaf Count	pH / EC Level	Observations & Notes
Week 1				Initial planting; roots starting to extend.
Week 2				New foliage growth observed.
Week 3				Nutrient water level check; top-up done.
Week 4				Final assessment and harvest stage.