Ecological Impacts of Rice Farming: Nutrient Cycles

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Introduction

An **ecosystem** may be loosely defined as the interaction between and among biotic factors, the various species involved, and abiotic factors, the conditions and resources of the system. Modern ecosystem theory divides an ecosystem into two interconnected subsystems: an **energy subsystem** and a **material cycling subsystem**. Because of *the Second Law of Thermodynamics*, the energy subsystem is an open system; energy enters the system as light, is transferred between organisms via trophic relationships (each transfer resulting in some energy loss), and the energy ultimately leaves the boundaries of the system as heat. As a result, ecosystems require a constant source of energy.

The nutrient subsystem in an intact ecosystem functions to a large degree as a closed system. That is, materials such as water, nitrogen, phosphorus, potassium, and other nutrients tend to cycle within the boundaries of a given ecosystem. These materials are taken up, assimilated, and stored by living organisms and are returned to the system as metabolic wastes or when organisms die. Decomposers and detritus feeders play a crucial role in releasing materials as forms that can once again be taken up by autotrophs.

Modern agriculture is a disturbance that has had a profound effect on these nutrient cycles. Significant amounts of nitrogen, phosphorus, potassium and many other minerals (i.e., calcium, magnesium, iron) are removed from the soil by crops; these crops are harvested and shipped to markets. This output of nutrients is substantial and must be replaced by the input of fertilizers or other agricultural methods. Thus, our agricultural systems are open systems, with inputs and outputs beyond the boundaries of the system (in this case, an agricultural field or rice paddy).

Rice Production Data (1999)*

Country	Production *('000 t)*	Area *('000 ha)*	Yield *(t/ha)*	Mineral Removal *(kg)*	Area planted with modern varieties *(%)*
Cambodia	3,800	1,740			11
China	200,499	31,720			100
Indonesia	49,534	11,624			77
Lao PDR	2,103	718			2
Japan	11,469	1,788			100
Pakistan	6,900	2,400			42
Thailand	23,272	10,000			68
Asia	540,621	138,503			74

***From:** http://www.cgiar.org /riceprodasia.htm

Purpose

The purpose of this laboratory exercise is to demonstrate and quantify nutrient and water loss in the production and export of paddy rice.

Materials

dried rice
crucible
crucible tongs
ring stand
safety goggles
drying oven (80º C)
balance
Bunsen burner
clay triangle

Procedure

1. Determine the mass of a clean crucible. Record this in the data table.
2. Fill the crucible 3/4 full with your rice sample and weigh the crucible and rice together. Calculate and record the initial mass of the rice sample.
3. Place the crucible and sample into the drying oven and dry at 80º C for at least 48 hours or until constant mass is achieved.
4. Remove the crucible from the oven and allow it to cool for a few minutes. Weigh the dried sample and record the dry mass of rice in the data table.
5. Place the crucible and dried rice sample into a triangle set up on a ring stand. Place a Bunsen burner beneath the crucible. Carefully adjust the ring so that the bottom of the crucible is in the inner cone of the Bunsen burner flame. Incinerate the sample until only ash remains in the crucible. ***Wear your safety goggles while your sample is being incinerated!***
6. Remove the crucible from the flame and allow it to cool. Weigh the ash sample and record its mass in the data table.
7. Calculate the percent water and percent ash (from dry mass) in your sample.
8. Repeat for three trials and calculate mean percent water and mean percent ash.

Data Table

Trial	Mass of Crucible (g)	Mass of Crucible + Rice (g)	Initial Mass of Rice (g)	Mass of Dried Rice (g)	% Water	Mass of Ash (g)	% Ash
1							
2							
3							
				Means			

Questions and Analysis

1. Explain the change in mass…
   a. after 48 hours in the oven.

   b. after incineration.

2. What are probably the major components of the ash that remains? What is their ultimate source?

3. a. Using the data provided, calculate the yield (tonnes/ha) of rice in 1999 for Japan, Indonesia, Pakistan, Cambodia, China, Lao PDR, Thailand, and for Asia as a whole. *Complete the data table on the first page.*

   b. Use the amount of ash you found and the yields above in this experiment to calculate the amount (kg) of minerals removed from the soil in Japan, Indonesia, Pakistan, Cambodia, China, Lao PDR, Thailand, and Asia as a whole. *Complete the data table on the first page.*

4. Describe the effects on the rainforest ecosystem when rice is cultivated, harvested, and exported from tropical Southeast Asia to Europe or the U.S.

5. Predict some ecological and technological effects of harvesting and export on the rice agricultural system and soil fertility.

6. Do you think that rice farming in Japan is an example of sustainable agriculture? How might it be made more so?

7. List some other environmental problems associated with rice farming in developed and developing countries.

8. Explain why different countries may have different productivity. Use your vast knowledge and the data in the table provided.