

Environmental Engineering Education at the Forefront of Water Resources Conservation and Wastewater Management

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This paper highlights the importance of water and water resources in the Philippines, the oil spill in Guimaras Island, the super typhoon “Milenyo” (Millenium), and the significant role of environmental engineering education in water resources conservation and wastewater management.

Key words: education, environmental engineering, water resources conservation

Introduction

Human beings, along with all other living organisms, live in a wonderful home called planet earth. Despite the presence of perceived and real dangers (wars and bomb threats) and other current difficulties, this planet is still our marvelous world remarkably prolific, hospitable and unique in the universe. By and large, compared with the conditions on other planets, our earth’s temperatures are relatively mild and constant. Plentiful supplies of clean air, fresh water and fertile soil may still be found in many areas. The earth’s amazing biodiversity of multitudes of living organisms creates complex and interrelated natural communities of flora and fauna, both in the macroscopic and microscopic world.

Cunningham and Cunningham (2006) aptly stated that human beings inhabit two worlds: the natural world and the “built” world of social institutions and artifacts created with the use of science, technology and political organizations. The process of integrating these two worlds causes tremendous tensions on both sides. Through the centuries, these tensions have resulted in problems on depletion and degradation of natural resources including water resources. Gigantic problems, like environmental problems, need gigantic solutions presented

in clear, simple, feasible steps and approaches.

There are many possible solutions. Even in the early 18th century, the conservationists already observed and understood the connections between deforestation, soil erosion and local climate change, which led to some orders and practices.

Proper education and training of all stakeholders is the strongest and most important strategic factor in the successful and active campaign against further environmental degradation. Former University of the Philippines (U.P.) President Gonzales, a voice from the not-so-distant past, aptly put it this way: *“If education has its sole object, the acquisition of knowledge, I doubt if the world could be long deceived into investing so much of its resources in it. Education must have demonstrated in the past that it is an effective tool with which to conquer new problems and to acquire new knowledge.”* (Gonzales, 1926).

This paper attempts to emphasize the significant role played by environmental engineering education in the conservation, development and management of water resources, including the wastewater generated by the agro-industrial sector. Education, as used in this paper, includes the process of attaining and integrating information and knowledge that can take place inside the academic institutions, and even beyond the university walls.

Methodology

The following activities were undertaken to enable the authors to integrate concepts and views on how environmental engineering education fits into water resources conservation and wastewater management:

1. Review of literatures on environmental engineering education, water resources and wastewater management;
2. Discussion with colleagues and other experts in water resources and wastewater management, in the Philippines and other Asian countries; and
3. Some research studies on adsorption of colorants from textile wastewater, using adsorbents produced from different kinds of biomass.

Importance of Water

All of us are stakeholders in water resources conservation. Early in life, we should be properly educated on the importance of water. We should be brought into a deeper level of understanding, even beyond the poetic and romantic notion of things about water.

Water (H₂O) is said to be the most common liquid on earth and vital to all living organisms. It is a chemical compound formed from the elements hydrogen and oxygen. Pure water is a colorless, odorless, tasteless liquid that freezes at 0°C and boils at 100°C at atmospheric pressure. Because of its high extensive hydrogen bonding, H₂O has a high melting point, high boiling point and high heat capacity. This high heat capacity results in very small temperature changes which are advantageous to cells where metabolic reactions are controlled by enzymes. H₂O can also participate in oxidation-reduction reactions as either a donor or an acceptor of electrons. The negatively charged oxygen atom attracts the positively charged hydrogen atoms of other water molecules, with the result that hydrogen bonds are formed between the water molecules holding them together. This makes water a very good solvent for other polar molecules and ionic substances. It dissolves both cations and anions. H₂O also dissolves gases such as O₂, CO₂, and N₂. As humans continue to use water in many ways, additional substances, including human wastes,

may be dissolved in water.

As a universal solvent, H₂O is vital in plant nutrition and growth. Roots absorb and transport nutrients dissolved in water. It also helps maintain the earth's surface temperature (along with CO₂ and certain atmospheric gases). The partial pressure of water vapor is generally highest near the earth's surface, and drops off very sharply with increased elevation. Water vapor absorbs infrared radiation (about 1 mm to 7×10^{-7} m) so strongly that it is significant in maintaining the atmospheric temperature at night, when the earth's surface is emitting radiation into space and not receiving energy from the sun. An extensive layer of water vapor is necessary to absorb and then radiate part of the infrared radiation back to earth. Otherwise, the surface loses of this radiation into space would result in a very high rate of cooling. In very dry desert climates, where the water vapor concentration is unusually low, it may be extremely hot during the day, but very cold at night (Brown *et al.*, 2004).

Human adults need approximately 2 liters of drinking water per day. About 5000 liters is used to produce 3.2 tons of paddy rice. Other valuable data that underscores the significance of water, are as follows: a) water covers approximately 72% of the earth's surface; b) human bodies are approximately 65% water by mass; c) the world ocean is huge with a volume of 1.35×10^9 km³; d) 97.2% of water on earth is world ocean, 2.1% is ice caps and glaciers, 0.6% is fresh water (lakes, rivers and groundwater), and 0.1% is brackish (salty) water, e.g. the Great Salt Lake.

Water: A Critical Resource

Current estimates on world population point to more than 6 billion human beings, with a projected additional 85 million per year. If the present trend continues, this may result in a population between 8 and 10 billions by 2050. The impact of the population pressure on natural resources and ecological system is definitely mind-boggling. There was a widespread thesis that the wars of the 21st century will be provoked by dwindling water supplies, but this has not been proven correct (Frank Kurschner-Pelkmann, 2006). Cunningham and Cunningham (2006) cited the findings of the United Nations Environmental Program, the World Bank and the

World Resources Institute, as follows: a) ≥ 1.2 billion people lack access to safe drinking water; b) ≥ 2.4 billion people lack adequate sanitation facilities; c) ≥ 5 million deaths per year, partly caused by polluted water (2.2 million children under age 5); d) approximately 40% of world population lives in areas where water demands $>$ supplies; and e) it is projected that by 2025 approximately 75% of the population could be living in water-depleted areas.

Water Resources in the Philippines

The Philippines has the longest coastline in the world, with its coastal area covering 60% of the country's 73 provinces. It is an archipelago with 24 major fishing bays and gulfs. It has rich inland waters consisting of 421 rivers, approximately 70 natural lakes, more than 106,328 hectares of freshwater swamps, and 30,000 hectares of dams and reservoirs.

Of the 421 river systems in the Philippines, a total of 40 rivers, including all rivers in Metro Manila, 4 in Cebu and 4 in Negros Occidental, have been declared biologically dead due to pollution. Mines are the major sources of river pollution. There are approximately 25 mining firms that discharge about 100,000 tons per day of mine tailings into the rivers. These contain acids, alkali, cyanide and heavy metals that gradually accumulate and become major hazards to humans and aquatic species. Industrial firms located along the banks dump wastes into the rivers. The Pasig River in Metro Manila is a waste sink to more than 150 factories that discharge 11 millions gallons of industrial wastewater per year (Ordonez, 2005).

Oil spill and fishing methods such as blasting, cyanide fishing and *muro-ami* have destroyed 95% of the coral reefs, thereby reducing the stock of fish.

Actual Cases: Oil Spill off Guimaras Island and the Super Typhoon "Milenyo" in Bicol Region, Metro Manila and Southern Luzon

Oil spill off Guimaras Island

The main source of oil pollution in aquatic environment is oil spills from ships, leaks from routine operations at tanker installations terminals and oil refineries, operational discharges from tankers and other vessels at sea. Sometimes, wastewater containing oil is deliberately discharged into the sea.

Oil spill kills all aquatic life because it is toxic. Coral reefs are also affected by oil spill. A coral reef is a wave-resistant underwater ridge mound built of fragments of coral, coral sands and solid limestone at or slightly below sea level. The Philippines has one of the largest reef areas in the world, approximately 27,000 square kilometers of coral reef area within a 15 to 30 meter depth. Of this area, only 5.3% can be classified as in excellent condition; 70% are deteriorating. Approximately 55% of the fish consumed by Filipinos depend on coral reefs. Similarly, production from coral reefs account for approximately 10 to 15% of total marine fisheries (Ordoñez, 2005).

On August 11, 2006, a single-hull tanker *M/T Solar-I* (owned by the Sunshine Maritime Development Corporation) navigated in stormy seas. The oil tanker sank 640 meters deep, 23.4 km from the southern coast of Nueva Valencia Guimaras town. Of the tanker's 2 million liters of cargo, the Coast Guard said that about 200,000 liters leaked out from the *M/T Solar 1*. From there, it was estimated that the tanker continued to leak around 200–250 liters of oil per hour. As of September 22, 2006 at least 58 barangays in 5 towns in Guimaras and two towns in Iloilo have been damaged. It was estimated that the oil spill has already affected 7870 families (39,004 persons) and Guimaras Island's ecosystem which includes 66 km of sea, 220 km. of coastline, 1143 hectares of a national marine reserve, and 454 hectares of mangrove- as well as people's health (1,706 reported sick) and livelihood. With continuing oil leakage, more than 144 kinds of fish, 29 genera of coral, marine turtle habitats, 7 species of seagrass, endangered *dugongs*, several species of whales and dolphins, and over 1,128 hectares of precious mangrove forest may be lost (www.wwf.org.ph; Phil. Daily Inquirer, September 25, 2006).

What has been done since the oil spill?

Petron Corporation (cargo owner) brought in consultants from Japan and voluntarily contributed in the form of Waterborne Industry Spill Response (WISE) tugboats, oil spill skimmers and booms, absorbent pads, and chemical dispersants. Use of dispersants has caused alarm among environmentalists. Containment and clean-up options have been made with an estimated 1,000 tons of oil debris

collected from Guimaras. Siphoning of bunker fuel is being negotiated with an insurance company.

Super Typhoon “Milenyo” (Millenium)

On September 28, 2006, the super typhoon “Milenyo” ravaged the Bicol Region, Metro Manila and Southern Luzon. As of October 3, 2006, 190 have been reported dead due to landslides, floods, giant billboards and other typhoon-related accidents. Again deforestation was the culprit for the destructive landslides and floods that claimed hundred of lives and several million pesos worth of crops and properties.

Could proper education and training have prevented such oil spills and landslides? Can they also provide short-term and long-term solutions to protect the fragile ecosystems in the Philippines, and elsewhere? The answers are in the affirmative.

Components of the Holistic Educational System

Education is a Process and a System

It is part of a learning process involving interactions and communications between teacher and students. Modern trends, however, show changing roles for teachers, from purveyors of knowledge to facilitators. The teacher endeavors to share and enhance precious knowledge with the students, using references and tools to facilitate learning,

hopefully in a conducive environment with several elements. These elements do not only refer to the physical location of the classroom or the school, but also include various socio-cultural, eco-political and even religious factors that influence the system. Curricula consistent with the learning objectives, together with the form and substance may be legislated by the government. Even the teacher, as an individual in a complex human society, is affected by his/her personal circumstances and beliefs. These, in turn, will determine the method, motivation, innovations and ultimate success of the teacher (Fig. 1).

Environmental Engineering Education

Cognizant of the importance of human dimension in environmental science , proper education and training should be provided to the concerned groups including government administrators, legislators, industrialists, engineers, academicians, teachers, businessmen, law enforcers non-governmental organizations (NGO’s), people’s organization (PO’s), “civil society (CS)” and the final consumers. Formal schools, mixed media (radio, TV, newspaper and other printed materials), music and some art forms (movies, theater, paintings, dance), initiatives of NGO’s, PO’s, and the “civil society”, are effective channels for instruction, and promotion of environmental awareness. Socio-political

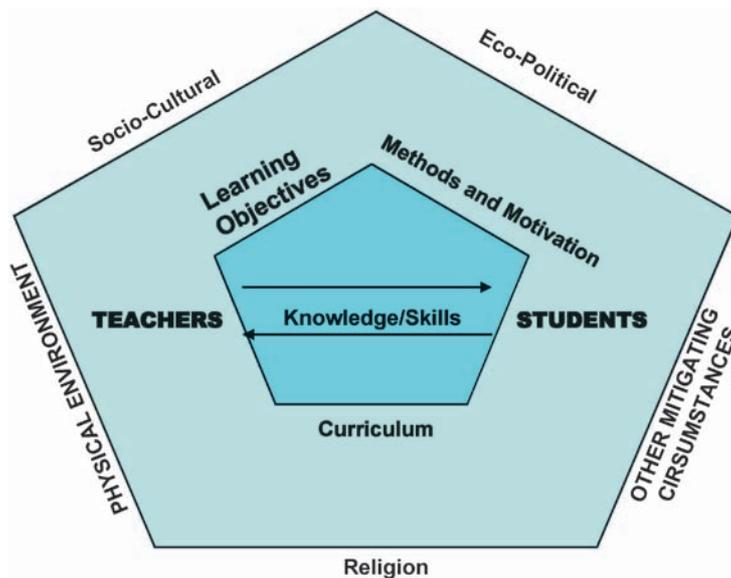


Fig. 1. Components of the Holistic Educational System.

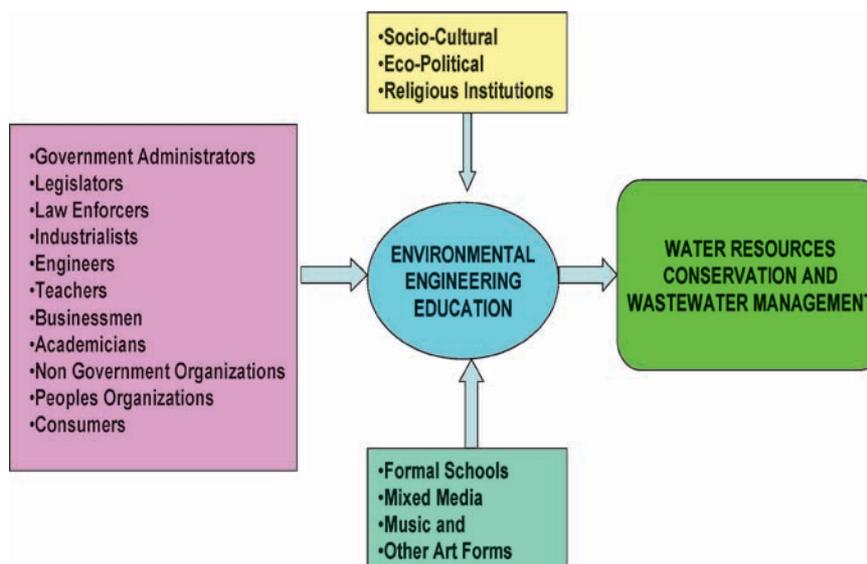


Fig. 2. Environmental Engineering Education of all Stakeholders.

Table 1. Some UPLB-CEAT Chemical Engineering Department Researches on Wastewater Treatment.

Process/Operation	Material treated	Agents/Reagents
Decolorization and COD reduction by adsorption	Distillery slop Crude Glycerol from methanolysis	Fenton's reagent Mixed Culture Activator Activated Carbon
Reduction of phosphates and surfactants by coagulation and adsorption	Synthetic laundry wastewater	Alum, lime, chitosan
Removal of Chromium VI by adsorption and hydrazine process	Simulated wastewater	Bentonite, hydrazine
Decolorization and BOD reduction by photolytic ozonation	Polymer lens, phenolic wastewater slaughter house wastewater	Ozone
Coagulation, photocatalytic degradation adsorption	Textile wastewater	Vermiculite, sunflower stalk, coconut husk, and other biomass
Coagulation-flocculation	Oil and grease from gasoline station wastewater Heavy metals in wastewater	Aluminum sulfate and anionic polyacrylamide <i>Rhizobium</i> exopoly-saccharide (EPS) Phosphono-methylated polyethyleneimine (PPEI)
Electrolysis and electroflocculation Reuse/recycle as diluent	Different kinds of wastewater Distillery slop	Electric current; flocculant Fish sauce/molasses fermentation
Modelling and simulation	Toxic inorganic and organic chemicals in Laguna de Bay (lake)	

and religious institutions also play significant roles in conservation and management of natural resources (Fig. 2).

For its part, the Chemical Engineering Department-CEAT-UP Los Baños has been conducting researches on wastewater management, mostly on end-of-pipe treatment (Table 1). Results of these studies may be accessed by fellow researchers and interested parties because they are published in journals, proceedings, bulletins and transactions. There are cases when affected industries and companies directly consult with the department faculty members about actual waste management problems. Hence, some of these results are directly conveyed to concerned companies.

Conclusion

Water is an important and critical resource that should be conserved. Its various uses have been discussed. The oil spill in Guimaras Island and the ravaging Super Typhoon "Milenyo" in the Philippines were included to demonstrate the damages

caused by malpractices leading to destruction. This paper also highlighted the significance of proper education and training in environmental engineering for all stakeholders.

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