ENVIRONMENTAL ENGINEERING EDUCATION AT THE FOREFRONT OF WATER RESOURCES CONSERVATION AND WASTEWATER MANAGEMENT

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SUMMARY

This paper highlights the importance of water , 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.

Keywords: 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. Its amazing biodiversity of multitudes of lives, 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 to 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 would be 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 which can take place inside the academic institutions, and even beyond the university walls.

METHODOLOGY

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

1. Review of literatures on environmental engineering education, water resources, 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 (H_2O) 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 colourless, odourless, tasteless liquid which freezes at 0^oC and boils at 100^oC at atmospheric pressure. Because of its high extensive hydrogen bonding, H_2O has high melting point, high boiling point and high heat capacity. This high heat capacity results to very small temperature changes which turn to be advantageous to cells where metabolic reactions are controlled by enzymes. H_2O 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.

H_2O also dissolves gases like O_2, CO_2, and N_2. As humans continue to use water in many ways, additional substances, including human wastes, may be dissolved in water.

As a universal solvent, H_2O 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 CO_2 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, so 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 this radiation into space and results to 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 about 2 liters drinking water per day. About 5000 liters is used to produce 3.2 tons paddy rice. Other valuable data which underscore the significance of water, are as follows: a). water covers about 72% of the earth's surface; b).human bodies are about 65% water by mass; c).the world ocean is huge with a volume of 1.35×10^9 km^3 ; d) of water on earth, 97.2 % 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. 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 to 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, though 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) about 40% of world population lives in areas where water demands > supplies; and e) by 2025, it is projected that about 75% 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 about 25 mining firms that discharge about 100,000 tons/day of mine tailings into the rivers. These contain acids, alkali, cyanide and heavy metals which 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 MetroManila 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 like blasting, cyanide fishing and *muro-ami* have destroyed 95% of 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 the oil spill from ships, leaks from routine operations at installations tanker terminal and oil refineries, operational discharges from tankers and other vessels at sea. Sometimes, wastewater with oil are 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, about 27,000 square kilometers of coral reef area within a 15 to 30 meter depth. Of this area, only 5.3% could be classified in excellent condition; 70% are deteriorating. About 55 % of the fish consumed by Filipinos depend on coral reefs. Similarly, production from coral reefs account for about 10 to 15 % of total marine fisheries (Ordoñez, 2005).

On August 11, 2006, single-hull tanker *M/T Solar-I* (owned by the Sunshine Maritime Development Corporation) navigated the 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 had leaked out from 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 had already affected 7870 families (39,004 persons) and Guimaras Island's ecosystem- 66 km of sea, 220 Km. of coastline, 1143 hectares of a national marine reserve, and 454 hectares of mangrove- as well as its people's health (1,706 reported sick) and livelihood. With continuing oil spill,

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 lost (www.wwf.org.ph; Phil. Daily Inquirer, September 25, 2006).

What has been done after the oil spill? Petron Corporation (cargo owner) brought in consultants from Japan and had its voluntary contribution in the form of the 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 1000 tons oil debris collected from Guimaras. Siphoning of bunker fuel is being negotiated with the insurance company.

SUPER TYPHOON "Milenyo" (Millenium).

On September 28, 2006, Super typhoon "Milenyo" ravaged the Bicol Region, Metro Manila and Southern Luzon. As of October 3, 2006, 190 were reported dead due to landslide, flood, giant billboards and other typhoon-related accident. Again deforestation was the culprit for the destructive landslides and floods which claimed hundred of lives and several million pesos worth of crops and properties.

Could proper education and training have prevented such oil spill 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 the interactions and communications between the **teacher** and the **students**. Modern trends, however, showed the changing role of 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 which influence the system. The kind of curriculum 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 (Figure 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 and religious institutions also play significant roles in conservation and management of natural resources (Figure 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 since these are published in journals, proceedings, bulletins and transactions. There are cases when affected industries and/or companies directly consult with the department faculty members re: actual waste management problems. Hence, some of these results are directly conveyed to concerned companies.

CONCLUSION

Water is an important and critical resource which 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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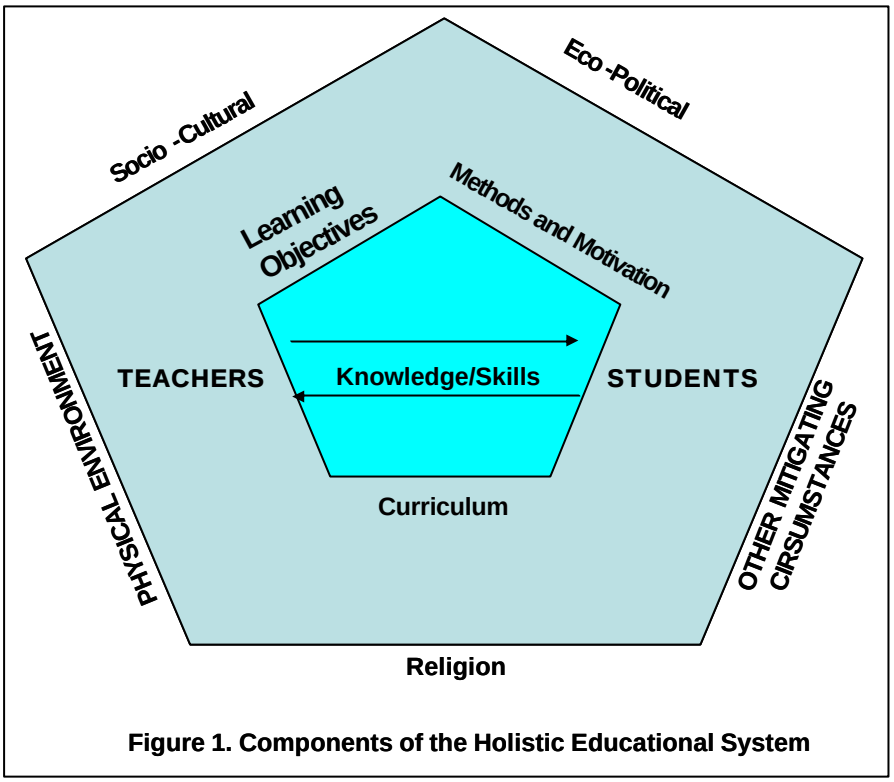

Figure 1. Components of the Holistic Educational System

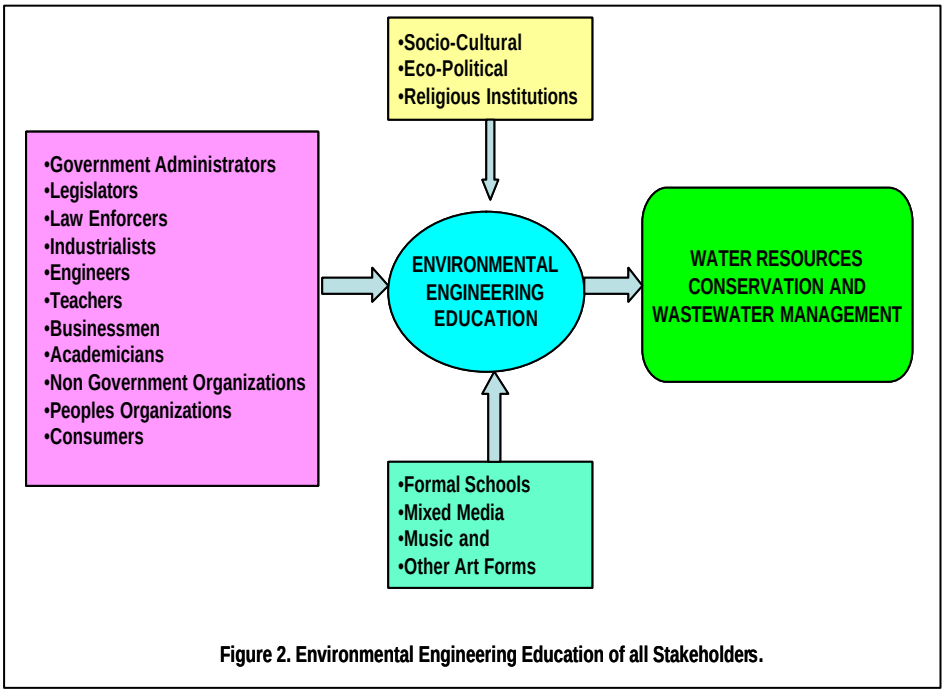

Figure 2. Environmental Engineering Education of all Stakeholders.

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	Fenton's reagent
	Crude Glycerol from methanolysis	Mixed Culture Activator Activated Carbon
Reduction of phosphates and surfactants by coagulation and adsorption	Synthetic laundry wastewater	Alum, lime, chitosan
Removal of ChromiumVI 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	Aluminum sulfate and anionic polyacrylamide
	Heavy metals in wastewater	*Rhizobium* exopoly-saccharide (EPS) Phosphono-methylated polyethleneimine (PPEI)
Electrolysis and electroflocculation	Different kinds of wastewater	Electric current; flocculant
Reuse/recycle as diluent	Distillery slop	fish sauce/molasses fermentation
Modelling and simulation	Toxic inorganic and organic chemicals in Laguna de Bay (lake)	