Teaching Biodiversity in Freshwater wetlands - A field based teaching strategy for school students

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Introduction

Wetlands are places where the land is covered by shallow water: marshes, ponds, the edges of large lakes and rivers, and low-lying areas that flood regularly. Wetlands brim with life: plants, microscopic animals, invertebrates fish, amphibians, birds and mammals. Wetlands also have their special plant communities - rooted plants like reeds, cattails, sedges, lotus and water lilies in the shallows and floating plants like duckweed and water hyacinth in deeper water. Lakes and ponds are inlets of lakes support a great diversity of plant and animal life. The muddy lake bottom is home to a host of creatures - flatworms, segmented worms, molluscs, crustaceans and insect larvae. The tangled roots of reeds and rushes provide shelter for breeding fish, frogs and newts. Water birds and a variety of mammals and reptiles nest and feed in the wetland vegetation near the shore. Wetlands are great places to see a wide variety of bird life. Birds that feed and breed in freshwater wetlands include ducks and geese, wading birds like sandpipers and plovers, gulls and terns, herons, cranes, fish eagles, and a huge number of smaller birds like kingfishers, weavers, warblers and finches. Wetland birds have adapted to life in or near water in many ways. Some ducks dabble in the mud for worms and crustacean with their heads under water, others dive deep to feed on algae growing on the lake bed.

Significant of Environmental Education

Environment based education increases specific critical thinking skills central to "good science" questioning, investigating, forming hypotheses, interpreting data, analyzing, developing conclusions, and solving problems.

The awareness materials produced by ZOO were used for freshwater wetlands conservation activities

Environmental education emphasizes cooperative learning (working in teams or with partners), critical thinking and discussion, hands-on activities, and a focus on action strategies with real world applications. As a result, students who study EE develop and practice the following leadership skills: working in teams, listening to and accepting diverse opinions, solving real-world problems, taking the long-term view, promoting actions that serve the larger good, connecting with the community and making a difference in the world. Using outdoor settings like wetlands, schoolyard habitats, or even national parks can infuse a sense of richness and relevance into a traditional school curriculum.

The environment-based approach to education lays the foundation for building students' problem solving skills. Environment-based education employs these key strategies for teaching creative and successful problem solving: introducing inquiry-based instructional activities with real world applications, encouraging critical thinking about these activities, allowing individual choice about and engagement in the particular problem to be solved, helping students make connections between disciplines, and fostering independent and cooperative group learning.

Sometimes traditional instruction, such as lecturing, is the most practical approach to covering broad content. But when students learn through a problem or project based approach a key strategy in environment-based education they gain a better understanding of what they learn, they retain it longer, and they take charge of their own learning key skills for success in our data-driven, rapidly changing world. They've become local experts in community stewardship, even educating local citizens, government authorities, and the press about environmental planning and protection. As a result of their service activities, students displayed fewer discipline problems and met with unprecedented academic success.

Environmental educators often find that students who fail in traditional

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Students are making mind map on freshwater wetland concept

school settings can succeed when the natural outdoor environment becomes the students' classroom. For example, students who learn best by doing can be as successful as students who learn best through lectures and books.

Environmental education – A global priority

The major two UN Conference on Human Environment, one at Stockholm held in 1972, the first Intergovernmental Conference on Environmental Education held at Tbilisi, Georgia 1977, and the second UN Conference on Environment and Development held at Rio de Janerio in 1992 have brought EE on the global agenda. The recommendations, particularly in Chapter 36 of AGENDA 21 (Rio– 1992), call upon reorientation of education (formal and non-formal) towards improving the capacity of the people to address environment and development issues. The agenda strongly advocates strengthening of awareness component for sustainability of earth's biological diversity. The Global Forum on Environmental Education for Sustainable Development, convened by the Indian Environmental Society (September 1993) recommended that, (i) EE should be integrated into the curriculum from the pre-primary to the university level, and (ii) teachers' training and their participation should be ensured through periodic programmes.

Indian scenario

Environmental education programmes in India gained momentum during the last three decades. While reviewing overall progress made under formal education, it is encouraging to note that EE components find satisfactory coverage in the school curriculum developed by the National Council of Educational Research and Training (NCERT). Likewise, in the non-formal sector, several organizations such as Centre for Environmental Education (CEE), Ahmadabad; Environmental Education Centre, Chennai (CPR); Bombay Natural History Society (BNHS) National Museum of Natural History, New Delhi, etc. have contributed in creating environmental awareness among students and community and as a component of formal education at the school level. However, the EE scenario at college, university level has not been impressive. Notwithstanding these efforts, in a country like India – with vast geographic area, richness and uniqueness of ecosystems, and diversity of socio-cultural environment, most of the EE programmes do not address issues of the entire nation. In this context, the education process needs to consider diverse features of this country. Therefore, development and implementation of EE perspectives to cover location, region-specific concerns would require specific strategies. Freshwater wetlands comprise suitable areas and subjects for involving students in ecology; they deserve special interest because of the variety of ecosystems, species and natural biotopes (Eirini Papapanagou, Argyro Tiniakou & Theodoros Georgiadis, 2005). The importance of the students being engaged in the exploration of concepts, issues and ideas often involves hands-on investigation into real-world sites, issues and problems and working collaboratively on relevant multi-disciplinary projects to which they can feel connected. It also requires the posing of significant questions that can be investigated (Cragg 1998, Lord and Orkwiszewski 2006). Fresh water wetlands is diversified with variety of living creature that constitute suitable areas and subjects for involving students in ecology and environmental biology; they deserve special interest because of the variety of living creatures, flora and ecological complexes. The Ousteri freshwater wetland ecologically diverse site is declared as bird sanctuary by the government of Puducherry and kaliveli tank is major freshwater as well as brackish water wetland and is one of the important bird areas in south India protected by Tamil Nadu forest department. Although many regulations have been introduced to combat non-sustainable activities within the wetland and its watershed, it has been subject to severe human

interference resulting in degradation of the natural environment. The aim of the present study is to use field trips for wetland biodiversity assessments and poses positive conservation behaviour.

Study area description

Ousteri lake is located between 79° 44.22' 11° 56.85' its spreads over 800 ha partly in Puducherry and partly in Tamil Nadu. The lake depends on its catchment for 75% of its water; the rest comes from diversion channels from Suthukeni. The lake is an internationally important site for migratory birds; the lake's most valuable use is for irrigation and ground recharge. The lake has rich floral diversity of over 200 species of plants belonging to 60 families. It has extensive aquatic flora of the floating, submerged and emergent type. The Lake is declared as bird sanctuary by the government of Puducherry and it also identified as Important Bird Area (BirdLife International, 2004). The study area experiences mean annual temperature of 30.0°C and mean annual rainfall about 1311-1172 mm. The mean number of annual rainy days is 55, the mean monthly temperature ranges from 21.3-30.2°C. The climate is tropical dissymmetric with the bulk of the rainfall during northeast monsoon October-December.

Biodiversity wealth of Ousteri Lake

The lake supports diverse flora and fauna. The flora consists of herbs 191, trees 103, stragglers 20, climbers 40, and grasses 63 species. The faunal diversity of the lake such as turtles 3, lizards 10, and snakes 16 were recorded. The avifaunal diversity was recorded 166 species both native and migratory. Butterfly 63 species were recorded in this lake. The fish species were found 25 including native and introduced (CMAP, 2011). The lake are under serious threats in the recent times, the lake exposed to various anthropogenic threats such as habitat loss, encroachment of agriculture, industrial growth, eutrophication, real estate, hunting and poaching were prevalent in the Ousteri bird sanctuary (CMAP Report, 2011, Azeez *et al*. 2008 and 2009). All these activities are resulting in reduce of biodiversity wealth of the Ousteri lake ecosystem.

Study area description of Kaliveli tank

Kaliveli Tank is located between 79° 50.00' 12° 10.00' its spreads over 7,500 ha is a semi-permanent, fresh to brackish water lagoon, which empties into the sea through a narrow channel connecting the tank with the Yedayanthittu Estuary to the northeast near Marakkanam. The water level in the tank fluctuates according to precipitation; the tank reaches its maximum extent at the end of the Northeast Monsoon, and in years of low rainfall, dries out completely for a few months during the summer. At such times, the encroachment of paddy fields reduces the size of the tank by as much as one third. The average depth of water at the end of the monsoon is about 1 m and the maximum after heavy rainfall, about 2 m. By the end of the monsoon, the lagoon is normally full of freshwater, from the run-off from neighbouring farmland. Subsequently, as the inflow of freshwater diminishes, there is some inflow of seawater from the estuary, and the lagoon becomes brackish, particularly at its northern end. The lagoon is occasionally flooded by seawater during cyclonic disturbances (Scott 1989). Yedayanthittu estuary lies about 3 km to the northeast of the tank. This estuary has large areas of inter-tidal mudflats, but only tiny relicts of the once extensive mangrove forests now remain. There are some 500 ha of saltpans alongside the estuary immediately to the north of the Marakkanam road bridge across the channel from Kaliveli Tank. Until about 25 years ago, the entire region was heavily forested, but almost all the forest has been cleared, and the tank and estuary are now surrounded by cultivation and scrubby thorn woodland. There are some low sand dunes by the channel linking the tank to the estuary. The Kaliveli watershed extends from Auroville Plateau south for about 30 km and has an area of approximately 25,000 ha (Scott 1989). These sites have a wide variety of sedges and grasses, interspersed with barren sandy areas and muddy margins. As the lake fills with freshwater in November, numerous aquatic plants germinate. Amongst the many species of algae in the brackish areas, *Enteromorpha intestinal* is particularly common. There are extensive reed beds and sedges in the less saline areas. A few straggly mangrove bushes are all that remain of what must once have been a large mangrove forest (Pieter 1987). The wetlands are situated amidst agricultural land and arid thorn scrub.

Methodology

Classroom session

The freshwater wetland education programs were conducted during 2013 August to February 2014. About 180 students from two schools in Puducherry and one school from Villupuram districts of Tamil Nadu, they were equally divided into two groups in each school one group kept as control and another group kept as experimental group in each school. The schools were selected around the wetlands as their livelihoods and recreational options are tied to these freshwater wetlands. At the beginning of the freshwater wetland education program, both groups were pre-tested to assess their existing knowledge and attitude on the basic concept of freshwater wetland ecosystem, its services, associated flora and fauna, threats and conservation. The students attitude assessment was assessed with standard questionnaire (Table 1) prepared by (Daniel, *et.al.,*) the questions with three point scale such as happy, impartial and unhappy with diagrammatic representations. The experimental group students were then facilitated with various active classroom interactive sessions which comprises student centred

Table 1 Questions related to students perception on freshwater wetlands

Questions related to students perception on freshwater wetlands	Happy	Impartial	Unhappy
Close your eyes and visualize you're in the Ousteri freshwater wetlands. You feel the cool breeze and hear the running water, how does it make you feel	91.7	8.3	0.00
You learn from a book that a variety of plants and animals live in the freshwaters of our own wetlands. What do feel about it?	50	50	0.00
You hear from a scientific report that the freshwater diversity of our villages is facing high level of threat. How does it make you feel?	0.00	41.7	58.3
Ousteri Lake is one of the important wetland in the Puducherry region rich in species diversity. How does it make you feel?	91.7	0.00	8.3
You learn from a learned source that freshwater plants and animals is a source of living for thousands of people. How does it make you feel?	50	33.3	16.7
It specifically reported that overall species richness and number of species in the Ousteri bird sanctuary are decreasing. How does it make you feel?	0.00	0.00	100
Many communities are directly dependent upon the resources that wetlands provide in the Ousteri lake. How does it make you feel?	8.3	41.7	50
In Ousteri lake found that 195 species of birds, 200 species of plants are threatened with various human activities. How does it make you feel?	16.7	8.3	75
Freshwater biodiversity provide value to human society by direct services such as fish for food or water purification for drinking and indirect services such as nutrient cycling, flood control and water filtration. What is your feeling about this?	83.3	0.00	16.7
Freshwater ecosystem support various orders of animals, plants and fungi, contributing to a quarter of vertebrates diversity and almost as much of the invertebrate diversity that has been described to date. How does it make you feel?	66.7	16.7	16.7
Some major threats to freshwater biodiversity of Ousteri lake/Kaliveli are overexploitation, water pollution, flow modification, habitat degradation and invasion by exotic species. How does it make you feel?	0.00	8.3	91.7
Assessing the status of species provides the means to monitor biodiversity trends and losses and helps in setting priorities for species conservation. How does it make you feel?	66.7	33.3	0.00
Poaching and hunting of birds, reptiles and other freshwater organisms are prevalent in Ousteri / Kaliveli freshwater wetlands. How does it make you feel?	16.7	0.00	83.3
This climate change and biodiversity education programs providing lot of information and changing my attitude and behaviour. How does it make you feel?	33.3	41.7	25
I visit lakes, ponds during my school holidays for enjoying nature and watch the biological diversity associated with freshwater wetlands. How does it make you feel?	83.3	16.7	0.00
I would like to live in a healthy natural ecosystem village, like undisturbed freshwater wetlands, natural vegetations and forests. How does it make you feel?	83.3	0.00	8.3

teaching learning educational methods lectures with power point presentations, debates, quiz competitions, games, drama, mind maps, autobiography, competitions and documentary film shows.

At the end of the program both control and experimental group students were post tested with same questionnaire as administered in the pre-test in order to assess the impact of field based biodiversity education on control and experimental group. Reports about the flora and fauna of the region are based on bibliographic data and our own field observations were prepared. For the pressures on the region's environment (threats, degradation) our personal observations were taken into account as well as data derived from standard publications.

A mind map is a graphical way to represent the ideas and any concepts. It is a visual thinking tool that helps structuring information, helping you to better analyze, comprehend, synthesize, recall and generate new ideas. In a mind map, as opposed to traditional note taking or a linear text, information is structured in a way that resembles much more closely how your brain actually works. Students in this freshwater wetland conservation program were assigned to draw a mind map related with nearby freshwater wetlands. At the initial stage they were drawn a simple mind map, after the complete wetland program they drawn a very complicated mind map related with freshwater wetlands its plant and animals and its threats.

Different aspects of wetland biodiversity exercises were carried out during the field trips. Three short exercises; biodiversity inventory of plants, faunal diversity such as birds, reptiles, arthropods (Butterflies and dragonflies), and identifying various threats to the biodiversity (anthropogenic and natural). Such

Table 2. Conceptual framework of ecological exercises conducted at Ousteri freshwater wetland of Puducherry

Exercises	Purpose
Plant diversity inventory	Students learn diversity of organisms in their local environment
Faunal diversity Inventory	Students learn diversity of organisms in their local environment
Assessment of threats to biodiversity	Students learn various threats to biodiversity both from anthropogenic and natural

exercises conducted 4 to 8 hours of total ecological exercises, (Table 2). At the end of the course, students were encouraged to use their abilities to convert observations in real ecological settings to the scientific process by developing individual projects.

Equipment, Sampling, On-site Lab Work and ecological methods

In order to create biodiversity assessments, it was important for the students in freshwater wetland education program not only to learn about the plants and animals associated with fresh water wetlands, but also students to understand how this biodiversity services to the human society, environment and its various threats can be assessed in the field. With basic field equipments such as forceps, nets, buckets, shovels, sieves, portable field water monitoring kits, binocular, small cameras and collection jars, the students surveyed the diversity of riparian vegetations and hydrophytes plants and animals living in the water and land. Different sampling strategies, such as transects and plots, were utilized to more systematically cover the area sampled, and for this, students used a tape measure and poles to map out the sampling plot for plant and animal studies. Because the richness of the students' experiences during a biodiversity course is dependent on unveiling this diversity, finding a successful sampling strategy is pivotal. The basic water quality tests were also conducted during the wetland study such as dissolved oxygen conducted at the spot in order to understand its significance of freshwater organisms in addition to this PH, temperature and nitrates were also assessed. The direct observation method was used to identify the various threats to bird's population both the native and migratory birds and its habitats. Identification of organisms collected in the field was based on detailed regional field guides for freshwater wetland that are catalogued at study area (Daniel, *et.al.,*).

Results and discussions

By experiencing students with freshwater wetland through the short wetland exposures, students discovered the fascinating biodiversity of the fresh water wetland in their own native place. They learned more about general concepts in biodiversity and lake ecology addressed in their textbook some extent as well as the ecological attributes of the local wetland plant and animal community. Students reported that the field level exercises also built up their hands-on experiences and a sense of nature. Overall, the attitude assessment survey indicated a significant difference between students' attitudes before and after taking the course ($F = 5.815$, $p < 0.028$). The short fresh water wetland field exercises mild modified students' positive values of the fresh water wetland biodiversity, particularly the belief that fresh water wetland field are sources of richness of biodiversity and livelihoods for local community.
Environmental education among students may not be fully developed unless the ecological exercises integrate approaches for building up environmental values (Eiss and Harbeck, 1969). An increase in average post-test scores of attitude and perception towards nature values indicated that ecological exercises that stimulate the affective domain necessarily sustain environmental awareness, ecological knowledge and skills. Field based environmental education can stimulate the affective domain of the learning process, limits students' practical knowledge and skills in environmentally responsible actions (Eiss and Harbeck 1969). In the present study students showed their interest on conserving fresh water wetland biodiversity as well as the wetland education was great source to improve student's creativity.

The freshwater wetland-based experiences improved student's attitudes and perceptions mildly changed conservation behaviour on local fresh water ecosystem. As a result, it is a solution for wetland protection and conservation that provides great opportunities for local students as well as student's perception and attitude changes to conserve these important natural precious ecosystems that serve livelihood options for local community as well sustainable environment. An inspiring biodiversity field course for school students need not be prohibitively expensive or difficult. Biodiversity field-based education coupled with the subsequent lab work will provide students with a new look at the natural world that would be impossible solely in the classroom settings.

Conservation of freshwater wetlands

The Government of Puducherry and Tamil Nadu has initiating various steps to conserve the important fresh water wetlands as one of initiatives the Comprehensive Management

Action Plan (CMAP) for Conservation of the Ousteri lake report done by Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore have suggested various management plans such as protection, prevention of encroachment and control of polluting activities, eco-restoration and initiating habitat improvement programs. Even though various environmental laws and policies empowered to conserve and protect natural resources, the effective environmental education will change the students attitudes, concerns and behaviour towards to conserve the local biological resources is very important in the conservation management plan.

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