NATURAL TREATMENT SYSTEMS FROM THE POINT OF DIDACTICS

SISTEMAS NATURAIS DE TRATAMENTO DO PONTO DA DIDÁTICA

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Received 23 June 2016; received in revised form 04 July 2016; accepted 8 July 2016

RESUMO

Todas as questões relacionadas com a ecologia ambiental e, entre eles, os sistemas Naturais de tratamento, obtiveram especial importância no século 21. É muito importante começar a oferecer aulas sobre SNT, os processos químicos naturais e agentes de poluição, nas escolas e universidades. Como estudo de caso, o artigo discute a metodologia de ensino do SNT na universidade e os níveis de básicos de ensino. A metodologia é orientada na realização de alguns importantes princípios didáticos em processo de ensino, que é uma ferramenta muito eficaz para aumentar a motivação dos alunos para aprender. Para análise comparativa, será utilizada a experiência de dois países vizinhos - a Grécia e a Turquia, para entender melhor as aplicações dos SNT na realidade. No artigo, são descritos os cenários de palestras e trabalhos de laboratório que estão ocorrendo na Universidade Estadual de Ilia, nos âmbitos dos cursos: Química Ecológica e Eco-turismo. Para aumentar o nível da popularidade do SNT, será uma boa experiência organizar palestras nos locais onde os SNT estão funcionando. O resultado do experimento pedagógico deixou claro que tal método de ensino da SNT afeta positivamente a motivação dos alunos e muda suas atitudes em relação a poluição ambiental.

Palavras-chave: Purificação de água; Didática do ensino NTS; Terras alagadas; História da química; Eco-turismo;

ABSTRACT

All the issues related with environmental ecology, and, among them, Natural Treatment systems, obtain particular importance now, in the 21st century. It is very important to start delivering classes on NTS, the natural chemical processes and pollution agents, at schools and universities. As a case study, the article discusses the methodology of teaching NTS at University and school levels. The methodology is orientated on realization of some important didactic principles in teaching process which is very effective tool for increasing students' motivation to learn. For comparative analysis, there will be used the experience of two neighbor countries - Greece and Turkey, to better understand the NTS applications in reality. In the article, is described the scenario of lectures and laboratory work which is taking place at Ilia State University, within the scopes of the courses: Ecological Chemistry and Eco-tourism. To increase the level of the popularity of NTS, it will be good experience to organize on-site lectures at the places where NTS are functioning. The outcome of the pedagogical experiment has made it clear, that such a method of teaching of NTS affects positively on students motivation and changes their attitude towards the environmental pollution.

Keywords: Water purification; Didactics of NTS teaching; Constructed wetlands; History of chemistry; Eco-Tourism;

INTRODUCTION

Environmental education is vital in the 21st century. It should be underlined, that future ecologists and biologists need such education, as well as those students and school-pupils who are not going to choose this profession.

Before asking the question, why for those who are not going to choose different profession, needed this kind of education, we can remember the three main goals of education that can be summarized in general terms as follows:

- The goal of personal growth, directed at stimulating students to shape their individual identity through growing experiences in the cognitive, affective and psychomotor domains.

- The goal of socialization, focused on preparing students to become responsible citizens through learning of social rules, accepting social roles and acquiring skills that are required for fruitful interactions with other people in society.

- The goal of qualification, directed at preparing students for employment in field that best suit their interests, ambition and abilities (Jong, O., Talanquer, V., 2014).

After this, the answer is simple. We all live in a common environment and each of us should be aware of the chemical and ecological characteristics of the environment, because of our personal growth, because of future qualification, because of being responsible citizens. In other words, if we won't take care of environment at least we shouldn't damage it. When speaking about the environment we particularly single out the water, because water-soluble agents (As known, there are not absolutely insoluble substance) are forming a stable soluble form, which spread through ground (or waste) water and pollute the soil, as well as surface waters. From here they will draw in aerosol composition and then spread in the atmosphere. From there, they return back to the earth, even in the composition of the acid rain and practically a peculiar circle is formed (Sutton R., Rockett B. 2008; Vanloon G., Duffy S. 2011). Therefore, we focus especially on the water and no less time is spent for the study of the contaminated water Natural Treatment Systems (NTS).

This article will discuss the different levels

of teaching methods of NTS.

MATERIALS AND METHODS

2.1. Finding

Issues can be taught on three levels.

With school- pupils we are talking about those issues on scientific-popular level. They, as well as students are the part of future society and it is important to make them aware now. We are giving information to them at scientific-popular lecture format. Such lectures are held at Ilia State University in two types of projects - "The New Enlightenment" and "The Science Café". During these lectures, the most important didactic principles are such as: 1. Dosed material supply; 2. Realization the principle of comprehensibility; 3. Inter-subject links.

We shall briefly review the mentioned didactic principles.

In dosed material supply is considered the brief overview of the NTS, their types and functions review and noting what advantage has each of them in treatment process. For what kind of pollution is used the NTS types and what are their advantages compared to conventional treatment systems. In the form of scientific-popular lecture we won't discuss the current process of NTS chemical or biological mechanisms. We are not discussing the processes in the NTS of chemical or biological mechanisms in the format of popular science lecture. We are not talking about the alleged hybrid forms. Realization the principle of comprehensibility means to show presentation about NTS. It is possible to show the video inserts (or lectures) and obviously, we will prominently use slides about countries with experience. At the Ilia State University professor K.Kupatadze guide popular lectures, where she used the information of experience of the two countries - Greece and Turkey. In Georgia we don't have the experience of using NTS. On the process of popular lectures (Especially school auditorium) in order to maintain the audience's attention inter-subject links are needed. In this case, it would be better if these links will be more unexpected. Naturally we will link the lecture about water and about its treatment to the biology and we will discuss the types of water in the human body, also we will connect it to chemistry and will list those pollutants that are

most often found in the water. In addition, we can compare different countries by the spread of pollutants from here (again, for example, Turkey and Greece). That is, what type of pollution is prevailing in which country.

As for the so-called unexpected inter-subject links (The leading chemistry didactics recommend using such links in the process of learning and they have a special sessions dedicated to international scientific conferences) (ICCECRICE 2012, ICHSTM 2013,), the topics of the lecture can be connected with the history of chemistry or to mythology (Kupatadze K. Gverdtiteli M. 2014). From the history of chemistry we can mention Lavoisier, who has done the analysis of water. We can also recall here Henry Cavendish, who discovered hydrogen, as well as Joseph Priestley and Carl Wilhelm Scheele, who discovered oxygen. However, very interesting fact is about the so-called monarch chemists, king Philip II of Spain and King of Georgia Vakhtang VI. Both of them were interested in chemistry. Philip II's had even gathered alchemical society at the royal court, which he financed very well and one area of his interest was water distillation and treatment with natural methods. In particular, he sought to purify water with rose petals (by plant) (Eamon C. 2010).

It is known that alchemists used to look for "philosophical stone" for speeding up gold transmutation process. The King Phillip II believed that "philosophical stone" was distilled, purified water. He also believed that purified water (purified with plants) was very useful for medicine as well. Paracelsus believed that "philosophical stone" was salt (NaCl), Glauber thought about another salt (Na₂SO₄) and only the king Philip judged in favour of the purified water. The king Phillip II used in water purification process methodology from Raymond Lully. One century before he served as alchemist in the royal court yard in England. This means that water purification methodology was known from the middle years.

Vakhtang VI reigned in Georgia in the eighteenth century, in the period when alchemy already was condemned by Robert Boyle and chemistry was announced as true science. Vakhtang wrote a book "The Book of mixing oils and making chemistry". This book is compiled by Vakhtang VI (Gathered by the King Vakhtang)

and includes records of various compounds producing (methods) (Vakhtang VI, 1991). Among the methods is mentioned treatment of water by plants from different admixtures. Practically, we can assume, that the king may have meant the wetland's plants.

Here, because we already talked about the example of Turkey, we can talk about Sultan Mehmet II (1453), who was interested in the metal alloys and he ordered to make cannon with a new method. Although we don't have information about his interest in the water, but it is still a good example in order to catch the audience's attention.

From mythology also can be given good examples. With water and hydrolyse is connected Hydra the daughter of Echidna and Tyfony, which was killed by Heracles. Limned were a type of Naiad. They lived in natural wetlands and caring about it. Their parents were river or lake gods.

It will be more effective to give information with a similar method on the popular level by field excursions on the place of natural treatment systems. It's very good opportunity in countries with experience. For example Kocaeli water and Sewerage administration (Turkey) has a good opportunity to arrange a similar educational excursions. In addition, on this kind of excursions it's possible to compare two types of treatment systems. For example, comparison of the natural treatment system in the village Balchik to modular system in the village Validekopru or to other different modular systems. Balchik village is to north of Gebze, it is surrounded by organized industrial zones and factories. This means that water purification process for the places like this is very important as well as spreading information about this among school students. Plant information is: plant is established over an area of 7,500m². It serves a population of 3000 people. Its average flow is 400m³/day. Treatment process in the plant is carried out with natural plants taken from straws. Horizontal subsurface runoff system at the 1st stage: 3 filled pond beds 15X45X0,8(m). Vertical subsurface runoff system at the 2st stage: 4 filled pond beds 25X30X0,8(m).

It is also possible arrange a separate study trip in Gebze waste water treatment centre. Gebze Wastewater Treatment Plant was built in order to eliminate carbon, nitrogen and

phosphorus from the Biological Oxygen Demand (BOD5). Plant treatment process is formed by Extended Aeration Biological Wastewater Treatment which is based on disruption of organic materials in wastewater by microorganisms, as defined physical treatment, the removal of phosphorus and activated sludge system (Assessment study (Turkish part), 2015).

We use different methodology for introductory course students. In Ilia State University these types of courses are undergone by first year students, who haven't chosen the specialty yet. The course is also taught on popular level but using more scientific principles.

The name of the course is: „Water – The basis of life“ and the following topics are discussed: Water in the history of chemistry; Chemical composition, structure and functions of water; Types of water in human body; Water as a solvent; Water pollution with heavy metals; Water pollution with organic pollutants; Acid rains; Treatment polluted water with constructed wetlands; Water circulation; Ocean water chemical composition;

Also there exists the second course “From alchemistry to 21st century”, where three lectures are dedicated to water pollution and natural treatment systems.

In the introductory course we discuss pollutant agent as well as types of natural treatment systems (in the case focus is made on constructed wetlands) and treatment process mechanisms (Sylaios G. 2014, Kiziloz B., Kupatadze K. 2015).

To the students of biology and ecology specialization noted issues are taught using slightly different angle and different methods. The course is taught with the methodology based on inquiry-based learning and methods which use strategy of “Big ideas” (Jong, O., Talanquer, V., 2014). Two main categories of big ideas are distinguished-contextual big idea (general, specific) and conceptual big idea (of chemistry; about chemistry). As specific contextual big idea to the students are offered water. As conceptual big idea and as one of the research areas are offered water pollutions and treated process by constructed wetlands.

Exactly in this context we can discuss natural processes (Table 1) running in the constructed wetlands (wetland vegetation, soil,

microbial activity) within a more controlled environment in order to remove pollutants. The main removal mechanisms can be divided in abiotic (physical and chemical) and biotic (biological) processes. The abiotic processes that are responsible for removing pollutants in a constructed wetland are:

- Settling and sedimentation, which contribute to particulate matter and suspended solids removal
- Adsorption and absorption, which take place on the surfaces of plants, substrate, sediments, and litter and result in short-term retention or long-term immobilization of contaminants;
- Chemical oxidation/reduction/precipitation, where influent metals convert to an insoluble solid form and are immobilized when water comes in contact with the substrate and litter;
- Photodegradation, oxidation and degradation of compounds in the presence of sunlight
- Volatilization - which occurs when volatile compounds partition to the gaseous state

Respectively, the biotic processes are:

- Aerobic/anaerobic biodegradation by microorganism metabolic activities
- Phyto-accumulation of inorganic elements
- Phyto-stabilization - the ability to sequester inorganic compounds in plant roots
- Phyto-degradation of organic and inorganic contaminants that enter into the plant during transpiration by enzymes that plants produce
- Rhizo-degradation by exudates that plant produce which lead to microbial degradation of organic compounds
- Phyto-volatilization/evapotranspiration achieved by plant leaves.

During the same courses students bring water from different regions of Georgia (mainly from where they are from) and analyze in the laboratory. Following analysis are conducted:
1.Determination of general hardness;
2.Determination of general acidity;

3. Determination of general alkalinity;
4. Determination of aluminum and heavy metals;
5. Determination of nitrates and nitrites content.

With the ranking method occurs detection of the most polluted regions water, as a result students in groups discuss which type of constructed wetlands (or it's hybrid form, with other natural treatment system) will remove more effectively above mentioned pollutants. From known three levels of water treatment on which level can we use any of the types of constructed wetlands. If the underground waters are polluted, then why free water surface wetlands are more effective and etc. and what is the meaning of sludge and how is it treated afterwards and used. Where or how can be used treated water.

Also one elective course exists "The field hydrobiology and ecological chemistry", where water pollution and its treatment with natural treatment systems means has dedicated a little more time and directly mechanisms of action are discussed with details. E.g. during the course, on the example of Greece, composition of two types of constructed wetlands and their comparison are being discussed - One is a free water surface (FWS) wetland system located in Pompia, Crete, south Greece, and the other one is a vertical subsurface flow (VSF) wetland system located in Gomati, Chalkidiki, north Greece (Tsihrintzis V. A., Akratos C. S., 2007).

Also the students discuss what influence can have water temperature, plant cover, pH and etc. on the effectiveness of the constructed wetlands. (Kotti I., Gikas G. D. 2010).

In scope of this course students will be gathering information about present conditions of wastewater treatment levels in Georgia. Untreated municipal wastewater is responsible for 67% of all surface water pollution. Industrial sectors strongly affecting surface water quality are: mining, oil production and food production. Other sources are: unsanitary landfills, illegal dumpsites and agricultural activities. Georgian rivers are mainly polluted with nitrogen or sometimes with heavy metals (River Mashavera, Bolnisi Region; River Kvirila, near Chiatara and Zestafoni) and rivers of the Black Sea in Adjara Regions are polluted with oil products. The main sources of polluting surface waters in Georgia are water supply and sewerage system, heat power engineering and industry.

The main pollutant for surface waters is communal sector (sewerage of towns and populated areas). Untreated municipal wastewater discharges into the rivers, and diffuse pollution from agricultural lands are considered as the main sources of ammonia and nitrite pollution in Georgia's rivers. In addition, legal and illegal landfills which are often located at river banks are significant polluters of rivers. The liquid substance which arises from the degradation of wastes, leachate, is highly toxic to aquatic life. It contains high levels of nutrients and heavy metals, and, depending on the type of wastes disposed of at the landfill may contain significant quantities of other hazardous compounds (Assessment study- Georgian part. 2015).

In scope of this course students also will gather information about natural wetlands in Georgia. They try to discuss the types of natural wetland and to find the ones similar to the constructed wetlands. In other words, according to water analyses, which are already made by them in the laboratory, they will try to discuss which type of wetlands is more effective for the removal of existing pollutant agents.

Among natural wetlands in Georgia there are considered the wetlands from Kolkheti Valley: Anaklia, Churia, Nabada, Malthakva, Pichora, Imnati, Grigoleti. From Javakheti Highlands there are considered the wetlands characterized with the following plants: *Caricetum diandrae purum*, *Caricetum inflatae calliargonelosum*, *Scolochloetum festucaceae equisetosum heleocharis*, *Scolochloetum festucaciae purum*.

It is necessary take in notice that wetlands (natural and constructed as well) are including in the world Tourist Route. Students of tourism management specialty undergo mandatory course "Eco-tourism". The main aim of the course is to introduce to students main directions in Eco-tourism (Laarman, J. G. Perdue, R. R. 1989).

Types of Eco-tourism include scientific tourism, nature history tourism, adventure tourism, travel on protected areas. In the listed types of Eco-tourism it is possible to consider local natural treatment system routs and giving tourists very interesting information. That's why, in one lecture of this course is discussed natural treatment system varieties, among this focus is on constructed wetlands and its types. Here, naturally, students (future employees of tourism sphere) are given only general information and

they should only know what type of area is needed for treatment system and with what design is it made.

Including zoos in tourist route will also be very good, as the world experience shows, that constructed wetlands are effectively used in zoos.

Here is another priority, it is also a habitat for wetlands birds. Also, in tourist routes can be included those protected areas, where constructed wetlands exist and on its example introduce visitors habitual plants of wetland, talk about treatment works conducted by them.

Inclusion of constructed wetlands places will be important for ecology, environment, as more people will get to know about them and will see themselves these types of places, will learn also how economically profitable are these types of treatment systems. Development of tourism will in turn benefit economy.

We don't have the experience of using constructed wetlands in Georgia and spreading information about them gains double significance. Consequently, in Ilia State University students are given information on three methodological levels discussed above.

RESULTS AND DISCUSSION:

At the end of the term we had offered an anonymous questionnaire to the students. Students from two introductory courses and from "Eco-Tourism" had participated in this opinion research (about 600 students). The questionnaire contained following questions (the test is anonymous and student names are unknown, they are requested to be as honest as possible): see Table 2.

The answers of students are following: (See in the Table 3 and 4)

According the student's survey, most of them are familiar with water pollution problem but information about Natural Treatment System is totally new. This information was received from lectures. The majority of students think that the gained knowledge will be useful for them as a non-chemist. As a non-chemists they will be able partly prevent water pollution. All 600 students agree that natural treatment systems are much more effective and cheap for small settlements. They do not damage environment, but needs

large area of land. After lectures students can recognize the most widespread pollutant agent and the possibility of their removal with natural methods. Most students would be visiting area with natural treatment system.

Tourism management students answered additionally two questions and according answers is clear, they would like to see natural treatment systems among the touristic routes because in that way people get additional information about environmental pollutions and maybe in the future will care about it. Also this will be useful for economy of country.

CONCLUSIONS:

The data of deductive experiment revealed, that most of the students didn't know about natural treatment systems. After completion of the course, they received information and formed certain idea about priority of these types of systems. The aim of the works conducted by us was exactly this: spreading information in tomorrow country society.

Apart from that, the methodology used in teaching gives effective results.

Here, must be noted, that survey was made with the students of two introductory course and eco-tourism. We have not conducted survey with students of biology and ecology, as they are taught the subject more deeply, in the regime of researches and discussions and the results are present with the presentations and works conducted by them.

ACKNOWLEDGMENTS:

An initial version of this paper has been presented (By K. Kupatadze and B. Kizilöz) in the WASTEnet Program Conference, "Sustainable Solutions to Wastewater Management: Maximizing the Impact of Territorial Cooperation", Kavala, Greece, June 19-21, 2015.

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Table 1. Removal mechanisms of certain contaminants

Pollutant removal	Process
Organic matter	Biological degradation, sedimentation, microbial consumption
Suspended solids	Sedimentation, filtration
Nitrogen	Sedimentation, nitrification/denitrification, microbial consumption, plant uptake, gasification
Phosphorus	Sedimentation, filtration, adsorption, plant and microbial consumption
Pathogens	Natural death, sedimentation, filtration, UV degradation, adsorption
Heavy metals	Sedimentation, adsorption, plant uptake
Organic compounds (pesticides, etc)	Adsorption, gasification, photolysis, biotic/abiotic degradation

Table 2. The questionnaire

Questions
Have you heard new information about water pollution?
Have you heard before about natural treatment systems?
Do you think, the knowledge gained will be useful for you, as a non-chemist?
What is your opinion about natural and traditional water treatment systems? Which one is more effective in action and adopted to the environment? Why?
Have you formed an idea about water pollutants and the possibility of their removal with natural methods?
If you had a possibility, would you visit constructed wetland of other types of natural treatment system?
To tourism management students also question was asked:
Do you consider as useful inclosure of natural treatment systems in touristic routs?

Table 3. Answers of students

Questions	Answers			
	Yes	No	Partially	Other:
Have you heard new information about water pollution?	400	20	150	30; Most respondent wrote, that they knew about the issue, though learned more deeply
Have you heard before about natural treatment systems?	0	572	28	0
Do you think, the knowledge gained will be useful for you, as a non-chemist?	470	30	100	0
What is your opinion about natural and traditional water treatment systems? Which one is more effective in action and adopted to the environment? Why?	600			All 600 answers were that natural treatment systems are much more effective and cheap for small settlements Doesn't damage environment, but needs large area of land;
Have you formed an idea about water pollutants and the possibility of their removal with natural methods?	575	0	25	0
If you had a possibility, would you visit constructed wetland of other types of natural treatment system?	501	80	19	0

Table 4. Answers of students

<i>To tourism management students also question was asked:</i>	Answers
For what will be useful inclosure of natural treatment systems in touristic routs?	For environm. 400
	For economy 100
	For informing tourists 100
	Other: 0
Do you consider as useful inclosure of natural treatment systems in touristic routes?	Yes-580
	No-9
	Partially-11
	Other: 0