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ECOLOGICAL CHEMISTRY THROUGH POPULAR SCIENTIFIC ARTICLES*Ketevan KUPATADZE**Ilia State University (Tbilisi, Georgia)*

Popularization of Ecological Chemistry is the aim of scientific-popular articles, which are published in the online journal for teachers. With the articles of this type Ecological Chemistry is linked with literature and history. Due to this linkage articles, this module turns into an easily comprehensible one and it becomes fun. In all articles there is also included very useful and interesting information pertaining to Ecological Chemistry. It must be underlined the titles of such articles, because they should not only show the common meaning of article, but they should also attract readers.

The utmost interest is generated by the historical papers, where chemical issues are connected with history. The period of alchemy is more popular and that's why the alchemical stories are described in the articles.

The outcome of the pedagogical experiment has made it clear, that such a method of teaching of Ecological Chemistry with scientific popular articles affects positively on school students motivation and changes their attitude towards the environmental pollution.

Keywords: *popular-scientific articles, didactic principles, interdisciplinary links, Ecological Chemistry popularization.*

CHIMIA ECOLOGICĂ ÎN ARTICOLELE ȘTIINȚIFICO-POPULARE

Popularizarea Chimiei ecologice este scopul articolelor științifico-populare, care sunt publicate în reviste online pentru profesori. Prin intermediul articolelor de acest tip, Chimia ecologică este legată de literatură și istorie. Datorită respectivelor publicații, acest modul este ușor de înțeles și el devine distractiv. Toate articolele conțin informații foarte utile și interesante referitoare la Chimia ecologică. Trebuie de subliniat importanța titlurilor acestor articole, deoarece ele ar trebui nu doar să redea succint înțelesul articolului, dar și să atragă cititorul.

Un interes deosebit trezesc documentele istorice, în cazul în care problemele chimiei sunt legate de istorie. Perioada alchimiei este mai populară, de aceea și sunt descrise în articole poveștile alchimice.

Rezultatul experimentului pedagogic denotă că o astfel de metodă de predare a Chimiei ecologice utilizând articole științifico-populare influențează pozitiv motivația elevilor și schimbă atitudinea lor față de poluarea mediului.

Cuvinte-cheie: *articole științifico-populare, principii didactice, legături interdisciplinare, popularizarea Chimiei ecologice.*

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 that are not going to choose this profession.

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 [1].

In the teaching process it is essential to continuously make students interested. There is a different approach and applying popular science articles are part of it. This paper reviews the popular-science articles on ecological and environmental chemistry, as one of the tools of chemistry popularization and getting students (and not only students) interested in ecological and environmental chemistry.

The popular-science articles, we are going to review, are published with the authorship of Prof. K.Kupatadze in on-line magazine "The Teacher" <http://mastsavlebeli.ge/> [2] and are targeted at wide range of readers. The key purpose of these articles is to amuse the reader while engaging them into reading.

The articles are in line with the didactic teaching principles.

In the framework of didactics and methodology there are some general didactic principles which deal with a pragmatic approach in teaching [3].

For example:

a) The Principle of combining theory and practice means to combine theoretical knowledge with practical activities. Each popular-science articles contains protocol of chemical experiment which can be after realized during chemistry lesson. Some of them can be carried out even at home.

b) The Principle of comprehensibility means that the learning material should always be adapted to the level of knowledge of the learners. The popular-science articles are written with easy language.

c) The Principle of using examples means that article always must contains a good practical example which can be used to make the contents easier to understand.

d) The principle of interdisciplinary links – In scope of popular-science articles Ecological and Environmental Chemistry are connected with other sciences – history, literature.

e) The principle of transfer of knowledge – In articles the chemical information is linked with everyday life.

How to make articles attractive

The title and introduction is the most importance when speaking about popular-science articles. Both (the title and introduction) will serve as "hook". If the title is of chemical nature, it will only have readers interested in chemistry. On the contrary, the title of the article should have no connection with chemistry and draw potential readers' attention by unexpectedness. As an example, I can name the article – **"What Can be Hard"**.

"What can be meant by the word "hard"? It might mean comma (In Georgian language, "comma" is pronounced the same as the word "hard"). Yes, you are right. It might have such great importance that it can change the whole meaning of the idea if skipped or put in a wrong place. What else can be hard? For instance: the life. It's a common topic of discussion... I could never understand why some people were awarded by hard life while the others enjoyed the easiest one. Furthermore, the one, who has been indulged with the easiest life, is no better than the one, suffering from hard life. It can be the opposite, but this is the reality and that's all – for some people life is as easy as a water flow, while for others – it is as hard as staying dry in the rain, but can one really feel others suffering?

Impression.. yes, it is also possible to be impressed heavily by something, or make heavy impression on others. However, the heaviness is perceived differently by various people. Terenti Graneli (a famous Georgian poet) wrote about heavy fate. Although, in the other verse he wrote that neither the fear of death was easy. Sometimes Galaktion's (Galaktion Tabidze, a well-known Georgian poet) heart was as heavy as the gates of Troy, to open for life. What else can be heavy?

Freight, an exam (may be the life test), a mistake... The latter may cause heavy consequences for doctors, teachers and chemists. A doctor does not have the right to play with someone's health and life. A teacher does not have the right to distort someone's spiritual world. Very often a chemist in his/her lab is entrusted with the others' health and life along with his/her own. Someone will ask-whether a worker standing on a scaffold has the right of mistake. No, he/she does not. Likewise, numerous professions can be listed endlessly. It turns out that each our blunder might be fatal.

However, not all the mistakes are grave. (the word grave in Georgians pronounced the same as words: hard, heavy, severe, comma). For instance, if a housewife mixes sugar with salt in a cake crême, that will not be an error in a big science. Furthermore – baking a cake is not a big deal. And even more, like everything, "heavy /hard" is a conditional concept. The life which can seem hard to me might be called by someone easiest, or, for instance, snowy weather is hard for me, while for someone it can be entertaining.

Therefore, let me write about what's really hard.

Heavy metals: mercury, lead, cadmium, chromium, manganese, nickel, cobalt, vanadium, copper, iron, zinc, antimony are considered to be especially dangerous by the UN Commission". Then article continues describing vanadium [4,5].

Among school students the period of alchemy is more popular and that's why the alchemical stories are described in the articles: **"Don't Play with this, it is Dangerous,"** concerning chemical properties of the element Mercury and giving some information about heavy metals and danger for environment.

"Very first time mercury was described by kitab sir Al-Halik. In his manifest was written: the body of mercury is white, soul and mineral is red. But if we will try making red compound artificially its turned into grey. A bit unclear, isn't it? Let's try making sense easier. Mercury white silver liquid metal. But in the nature there is red crystal-Cynober, which is sulphide of mercury. But if we will make reaction between sulphur and mercury in the laboratory than we will have the same mercury sulphide but in grey colour."

According Al-Halik among the Earth's "spirits" mercury was the most important, at the second place was sulphur, after-ammonium and arsenic".

"Zeus's Rain" is the title of other article, dedicated to the history of the element Lead. The name is taken from a chemical experiment, which is called "Zeus's Rain" and where nitrates of lead are taken as reagents.

The experiment is connected with a legend, according to which, Zeus came to imprisoned Danaë in the form of golden rain [6,7].

Article – **“Excuse me, are you a Paracelsus?”** deals with cadmium.

“Now it is warm outside... Smell of spring subtly touches my olfactory senses. Though born in winter, I am not fond of this season of the year and every time it comes, a strange feeling of sadness seizes my soul. Nor I am a worshiper of wintry Tbilisi. Cannot help agreeing with Tato (nickname of the famous Georgian poet Nikoloz Baratashvili) and admitting that in cold weather “Tbilisi is a city of melancholy and grief”. Anyway, you can never judge by my appearance what grievance I am bearing, as nobody is actually interested in what you feel, the world requires you only smiling. I paused for a while...It is decided, I will take a walk in such a beautiful weather. I am going home and no reason to hurry up.

Suddenly my attention is caught by a man in front of me. He should be about 70. He is walking too. Having a habit of going fast, I am leaving him behind in a shortest while, for I want to take him in at a glance. First I slightly overtake him, then turn back and after a while follow him. He has a stocky configuration, not tall, with ruddy cheeks, broad forehead, and back combed hair. He does not even notice that he is being observed. I am burning with desire to approach him and ask:

– Excuse me, are you Paracelsus?

But I do not ask. First of all, he won't understand, second of all, he will refuse by all means, saying that I am mistaken and will start reciting all day long how he was associated with some Para... Wait a minute; let him remember... in short... with some zzel. Or may becelsus? (This is a play of words)... or to an ax (play of words). One can not understand these people...

In order to avoid any accusation or misunderstanding, I will tell you, that Paracelsus was an alchemist. This strange name was taken as a pseudonym, his real name was Philippus Aureolus Theopastus Bombastus von Hohenheim. He tried to compete with an Italian doctor, Avlus Kornelius Cels claiming to be superior to him. That's why he called himself Paracelsus, i.e. superior to Celsus. Although being an alchemist, he used to practice in medicine as well. Or maybe on the contrary, apart from being a doctor, he also practiced in alchemy. He was searching for a philosophers' stone both for obtaining gold and for medical purposes. That time, two major issues were of concern: life prolongation and rejuvenation. In medicine, Paracelsus believed that blood was the most important thing calling it the main liquid. As for alchemy, he thought that Zink or table salt would act as an accelerator facilitating sulfide's (which was made of mercury and sulfur powder) transformation into gold". Despite the fact that the reader might be thinking that the next paragraph of the article will deal with zinc, it continues with describing cadmium, as this is the very element, dispersed during zinc extraction from deposits, harming the environment [8].

Amusing stories serve as a good “hook” as well. The author of the article **“Smog”** begins with the story how he started to learn Turkish language.

“In these latter days I attend courses in Turkish language. We have a teacher, named Esra, long haired and black eyed young woman. She does not know Georgian, but tries her best to learn it. The class is staffed with students; I am the eldest among them. However it does not make me uncomfortable and I am entirely engaged in the learning process. There are only two boys in the class, the rest are the girls and it's not a surprise that there is much noise considering the number of girls assembled together. Esra Hoca (Teacher Esra) knows a couple of Georgian words, that's why sometimes she shouts out with a warning tone:”Gogolar (gogo – means a girl in Georgian), this is a mix of Georgian-Turkish. A girl is pronounced in Turkish as “kız”, in plural – “kızlar”, however “gogolar” is somehow different, affectionate and strict at the same time.

You can ask her anything ten times, she won't get tired of explaining with the same energy and enthusiasm. All was the same that day, when she was teaching us about clock, tirelessly drawing various versions of time on the board asking the question “kach Saat? (What time is it?)”; one of the girls joked in Georgian, our Hoca is like fire. And as if someone had asked me I immediately translated to the teacher: “You are the woman like fire”. At first she couldn't understand, and then we explained that it meant an energetic person and being like fire was considered to be a compliment in Georgia.

By the way, after early alchemists, fire was first looked at by Jan Baptist van Helmond, followed by Georg Ernst Stahl, and finally by Lavoisier. Each of them saw something different in fire, although all of them agreed that combustion processes took place during fire. And what if combustion process is incomplete? Yes, gases are released and the very smog is formed from these gases.

Today we are going to talk about smog.

In 1661, John Evelyn described London's atmospheric air in his book "Fumifugium". He wrote about strange smoke and smog sometimes formed in London, which made it difficult to see anything and made an impression as if the air was full of ash after volcano eruption [7].

After reviewing smog chemically, the article ends with a funny story.

Once upon a time, a girl and a boy lived in a small borough. They fell in love with each other and met every day. Someone told the girl's father that his daughter was in love with the boy of another man. The girl's father was strict, and he got furious....How she could have dared! He locked up the girl in the house and forbid her to go outside. The girl stopped to eat in protest and declared that she didn't want anyone but him. On the third day of hunger, she started thinking about what her lover was doing while she was sacrificing herself and sent a letter with the help of her sister. (There was no telephone and internet that time). The boy suggested running away from home that night after her sister had unlocked door. And they did so, but the girl's enraged father pursued them armed with lots of bullets.

Esra Hoja paused here

– Then? What happened then?

– How do I know what happened? You have to think yourself! I told the story for I wanted to put the verbs in the past tense and to make you get used to it. Now we are going to learn how to use verbs in the past tense.

Past tense is necessary of course; however the story must be ended. We can not allow the father to kill the fleeing kids through the double-barreled shotgun, can we? Look, I've got an idea...

The boy and the girl entered the town before the chasing father. There was smog everywhere in the town... So, the father could not see anything, he had never heard about fog either. Finally he gave up and came back to his village. We are going to talk about the family and the number of children the couple will have at our next discussion when explaining the future tense.

Several articles refer to water and its pollution: "**Water – Origin of life**"; "**Once Again on Water**"; "**Kocaeli, Izmit, Nicomedia**". The first two articles deal with water properties and its distribution, while the third one – refers to water pollution and its natural treatment systems.

– "Welcome to Turkey, I wish you a happy day, – a customs officer is giving back my passport with an artificial smile, opening the entrance door of the country. – Thanks, likewise" – I am answering with the same smile.

What a happy day – It is raining cats and dogs. I am looking for a person holding a big paper with my name on it, to drive me from Istanbul to Kocaeli. Kocaeli is near Izmit. This is old Nicomedia, located next to Constantinople (now Istanbul) with the shores flaunting in the Sea of Marmara. The city was founded in 712 B.C. and was called Astacos. After being destroyed, it was first rebuilt by King Nicodemus; therefore the city was named after him. Plinius Junior wrote about the landmarks of Nicodemia in his letters, commenting how great it would be to install water pipes and lay the channel between the inner lakes and the gulf of Nicomedia.

So, if we drive along this Gulf, we will get to Kocaeli. It takes half an hour to drive there from Izmit, and about an hour and a half – from Istanbul.

Kocaeli inhabitants are proud of having potable water running directly from taps. Drinking water is taken from the Mount of Chenesuyu (Çenesuyu), which is famous for its quality and purity. They take pride in the whole network of natural treatment systems and take special care of the cleanliness of water.

Today I am going to talk about water for the third time, however - now our discussion will refer to its pollution and treatment" [9].

The articles "**Story written in a terminal**" and "**I am thankful to you, my king**" deal with the very interesting fact 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) [10]. 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.

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) [11]. Among the methods is mentioned treatment of water by plants from different admixtures. Practically, we can assume, that the king might unconsciously have thought about ecological chemistry.

Results and discussion

We had offered an anonymous questionnaire to the students and school students. Students from two introductory courses and from biological specialization had participated in this opinion research (about 800 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 1. The answers of students are following: (See in the Table 2).

Table 1

The questionnaire
1. How often do you read popular-science articles
2. Will it be useful for the student of other specialty to read such articles?
3. Chemical contents outlined with easy language?
4. Which field is more important to link with chemistry in articles like this to make them interesting?
5. What kind of chemical content is more interested for you

Table 2

Questions	Answers of students			
	Yes	No	Partially	Other: (If you chose the last answer, please, explain)
How often do you read popular-science articles?	500	20	250	20 lack of time; 10-the articles are uninteresting for them
Will it be useful for the student of other specialty to read such articles?	780	0	20	0
Chemical contents outlined with easy language?	800	0	0	0
Which field is more important to link with chemistry in articles like this to make them interesting?				725-with amusing stories; 40-with history of chemistry
What kind of chemical content is more interested for you				500-Ecological/Environmental chemistry; 100-Food chemistry; 160-Biochemistry; 40-General Chemistry

According the student's survey, most of them often read popular-science articles. They read because it is interesting and the chemical information is conveyed simply and clearly. It is also significant that besides chemistry, it provides other valid information as well. However, the interview revealed those too, who don't read such articles and named the lack of time as an excuse. But the smallest part of them considers such articles to be uninteresting. The majority of students believe that reading such articles will be very useful for students having other specialty, since many articles refer to environmental and the so cold "household chemistry".

The majority of students believe that chemistry should be related with amusing stories in the articles of this type. Other part of students prefer to connect chemistry with history and poetry.

Conclusions

The data of deductive experiment revealed, that most of the students likes popular – science articles and find them interesting and useful at the same time. This kind of articles makes it easy to inform wide range of readers, giving them information with chemical contents.

Articles on environmental chemistry enable the future generation (the citizens and the decision – makers of tomorrow) if not becoming a chemist, to get environmentally educated and be aware of the significance of environmental safety.

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