Non-formal Education Outside Buildings: The Case of Shore Chemistry

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Abstract

There exists a large number of studies about non-formal education in education, less about chemistry, and a few or none related to coastal chemistry. The disappearance of chemistry had been identified by several authors, not only in the context. In this article we present an approach to education based on guided inquiry on materials and traditional and industrial processes that can be seen outside laboratories and classes, giving the specif example of marine and shore chemistry, aquaculture, and daily-life products. This inquiry can be stimulated and conducted by specific internet sites like "Percursos Quimicos" ("Chemical Trails"), mobile phone applications, leaflets, or specif kits, and others. Pupils can bring to the classes their observations and questions and the teacher can suggest also other observations, following the official programs of teaching. This is especially interesting when pupils are not in school due to pandemics or other reasons.

Keywords: *Chemistry and Society, Water, Shore, Daily life products and processes*

1. Introduction

Several educational studies and proposals point to the usefulness of non-formal education for motivational purposes, as well as the interaction of these and informal education with formal education [1-3]. Also, there are some studies on the value of field trips and other outdoor activities in promoting education [[4-7]. In Portugal, it is also possible to allocate time and classes to these projects and contribute to formal education throughout DAC (domínios de autonomia curricular, domains of curricular autonomy) and others. There some non-formal projects in chemistry [8-12] but a few are related to shore chemistry directly. Moreover, they appear to be underrepresented (see, e.g, [12]) and do not solve the disconnection between the general public and scientists [13].

The chemical trails idea was proposed and implemented in Great Britain by Borrows (see, e. g., refs [6, 14]). This concept was implemented in Portugal by Rodrigues [15] (written mainly in Portuguese but a few are translated to English) and it was used in several contexts. From formal classes to non-formal education, from formation for pre-service teachers to formation of teachers along-life and others. Some of the activities are implemented in mobile phone applications [16] The concept is useful also without definite locations. The main idea is to develop this project outside buildings and the trail can have various locations. Of course, there are places very definite, but some processes are similar everywhere. This is what happens with shore chemistry.

The newest entry in the blog "Percursos Químicos" ("Chemical Trails") is based on the Portuguese Saint James Way but the other entries are on beach and shore chemistry. This way includes largely coastal routes [17-20] in Portugal and Galicia. In Portugal it passes in Vila do Conde, Póvoa do Varzim, A-ver-o-mar, Apúlia, Esposende, Viana do Castelo, Vila Praia de Âncora, Moledo, and Caminha, for exemple. There are plenty of beaches and shore vegetation. But also the memory of the traditional arts can be found. In Caminha, for example, we can found brown algae now used mainly as natural manure but in other places, it is used to extract bromine and iodine. The form of obtaining these elements is seaweeds. Moledo is also very well known for its maritime spay rich in iodine.

In Galicia side it passes though A Guarda, Portocelo, Oia, As Marinhas, Baiona, and Vigo. In Baiona we can visit a replica of the caravel "Pinta" used by Colomb to discover the way to America. At Vigo, we can visit the sea museum where a roman vaporization marine can be found. Curiously, the traditional salt marshes, with their salt production facilities, that are in use today, are based on the same principle. The tanks are shallow and large for the vaporization and the subsequent increase in concentration to be maximized. In the firsts tanks, the increase of concentration precipitates the iron salts, then in the next tanks, the calcium carbonates and sulfates are precipitated. It rests the very

soluble salts, sodium chloride, or bromide of potassium. The increase of concentration eventually leads to the precipitation of these also. For NaCl, this happens around 37%. An obvious question and obvious finding are that no infinitely soluble salts exist.

In chapter VIII of the second part of Jules Verne's book "20,000 Leagues Under the Sea", called "Bay of Vigo" there is some interaction with history and geography. Rodrigues [21] refers to various other interactions. In As Mariñas we can found several interesting things, like beacons, water filtration plants, and others. The beacons (old and new) can have large quantities of mercury for the rotation of the heavy parts. The water treatment plants increase the rate of the natural process of cleaning the water. The chemical products and processes eventually used, are for drying the mud, and to eliminate drugs, medicines, nitrates, or other products. In tap water, the presence of small quantities of chorine is to maintain its protection against bacteria along with the network.

The traditional and modern fishing methods and processes can also be seen along the shore. Also, some aquiculture plants can be found. A review of aquaculture was recently made by one of the authors of this paper [22].

Also on coasts, we can verify the water quality, measure their pH and detect contaminants. A red cabbage indicator can be used or special equipment.

2. Methods

The chemical trail can be used as a source of information or questioning. In the present paper, we think of them as the origin of inquires. Why the water in blue, green os sometimes gray? Why the fishes are usually shinning? Why the sand is golden? Why sometimes we can find large quantities of mercury in beacons? What is the pH? How color indicators and devices measure de pH? What is concentration? What is the concentration of plastics in the ocean? Do treatment of water uses chemical products? Why tap water uses a very small quantity of chorine? What are the concentration and quantities of gold, plastic, and other things in the ocean? As sodium chloride is very soluble how can we obtain it by precipitation of the solid? We can also state more moral questions. What is the real state of the world? What can we do to obtain a more sustainable world? What can we do to solve certain problems? What the scientists and decision-makers can do to solve certain problems?

The questions and inquiries involve also critical thinking. Are the questions relevant? The process is really like the question appears to state? Some questions do not even are not made. Others can be based on misconceptions. And also the answer depends on the one that answers. "Why the fishes are usually shinny?" A biologist may say that they develop this strategy to hide from predators, a physicist may say that they reflect all wavelengths like a metal. A chemist will say that they have a special polymer in their scales. Eventually, all are right.

There are also very specific subjects and questions. One such question that is transversal to chemistry is about the Avogadro constant. It is relevant? Yes, as many processes are much influenced by this constant. And also because is difficult to visualize such small entities and big numbers.

Statements must always involve some skepticism and critical thinking. A sentence like "a glass of water has much more molecules than the number of glasses of water in the ocean" can be verified?

Some statements involve calculations and critical verifications. For example, gold in the sea has a very low concentration (20 ng/L or $2x10^{-8}$g/L), but due to the very large volume of water in the ocean ($1,3x10^{21}$L), the total mass of gold is impressive (26 million tons). This simple example shows the striking differences in intensive of extensive properties, and how the small as big numbers can be misleading, in particular when involving the Avogadro constant. Another example is the microplastics in the environment. The number of pieces reported can be impressive, but the concentration is still very small. This does not intend to minimize the deleterious effects of plastic debris in the environment, but only to put it in the right context.

3. Conclusions

The "chemical trails" are available through the internet, mobile phone applications, and other media. In the present paper, we show their use in non-formal education, in the case of coastal chemistry

connected to water and ocean, but the main issue is their use in activities, formal, non-formal, or informal, outside buildings. We believe that they are valuable as an educational tool.

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