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# Didactic Strategy for the Teaching of Isotope Mixing Models for Stable Isotopes Relevant to Biogeochemistry Based on the Analogy with Color Composition

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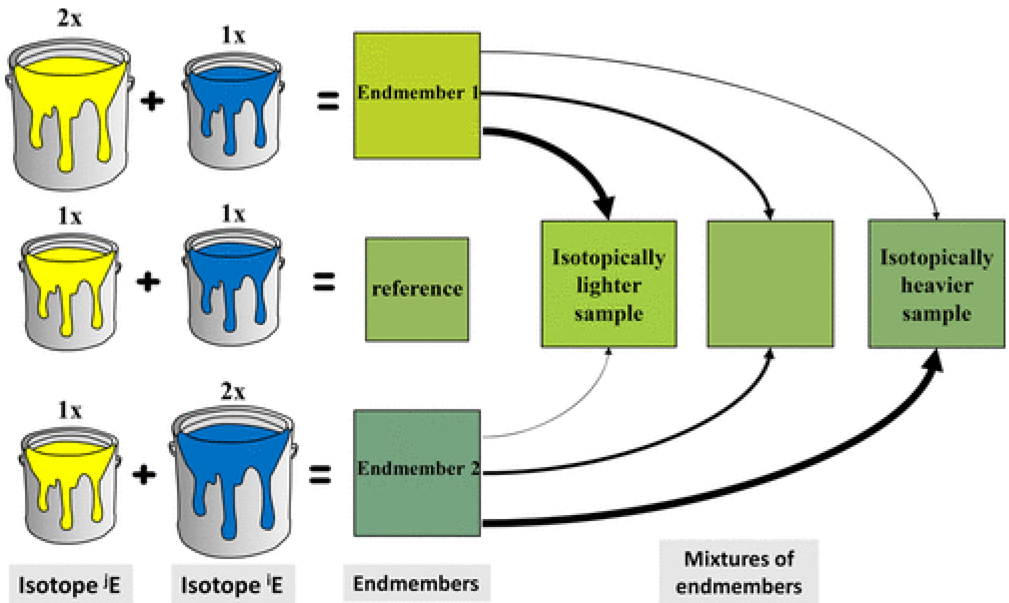
**Abstract :**

The continuous advances in mass spectrometry techniques have pushed forward the frontiers of all branches of the isotope biogeochemistry field. In environmental studies, different isotope ratios as determined in different reservoirs offer the opportunity, for example, to identify pollution sources and to trace metal fluxes within the trophic web and in dietary studies. Despite its relevance, trace metal isotope biogeochemistry is infrequently taught in undergraduate courses because it demands a rather high level of complexity of teaching strategies and abstraction capacity from students. Additionally, available didactic material for introducing mixing source modeling with stable isotopes relevant to biogeochemistry is scarce. In this context, the present study applies a visually appealing didactic strategy based on the analogy between colors (analog domain) and isotopic compositions (target domain), in order to encourage and assist the teaching–learning processes of this new subject in environmental science and chemistry classes. We demonstrate how familiar and simple concepts can be applied for introducing challenging subjects. In a setting that restricts in-person academic activities such as during a pandemic, the development of appealing visual approaches is imperative to engage students during online classes. The didactic strategy proposed herein was put to the test during remotely taught classes on the topic of “Environmental Impact Assessment Methodology” (winter 2021, 18 students) and “Environmental Contamination” (summer 2020, 18 students, and winter 2021, 20 students) of the Postgraduate Program in Geochemistry at the Fluminense Federal University (Rio de Janeiro, Brazil). Students’ feedback was very positive; they found our approach stimulating, and it helped them to better visualize, understand, and interpret the targeted learning outcomes.

**Graphical abstract**




**Keywords** : Upper-Division Undergraduate, Graduate Education/Research, Interdisciplinary/Multidisciplinary, Analogies/Transfer, Distance, Learning/Self Instruction, Isotopes

Variations in isotope abundance derived from biogeochemical processes (in the case of stable isotopes) or radioactive decay (in the case of radiogenic isotopes) provide a useful tool to quantify source contributions. These models are commonly used in context of pollution source identification, magma contributions, trophic web and dietary studies, and many others.[1-5] Despite the importance, isotope biogeochemistry is not regularly taught in environmental sciences and chemistry courses at undergraduate level, and available didactic materials are scarce. Furthermore, introducing isotope mixing models is challenging since it demands high learning capacity from undergraduate and graduate students.

We present here a new approach to teaching source mixing processes using isotope models, employing a visual didactic strategy based on the analogy between colors (analog domain) and isotopic compositions (target domain). The concept takes inspiration from the textbook "Stable Isotope Ecology" by Brian Fry:[6] "Fractionation creates the artist's palette, the isotope colors that are later mixed and arrayed to form the grand isotope masterpieces of nature" and "Isotopes function as natural dyes or colors, generally tracking the circulation of elements." The color analogy is also described in the Manual for the Use of Stable Isotopes in Entomology (IAEA, 2009).[7]

Analogies are comparisons that highlight similarities between the structure of the target (unknown) and analog (known) domains. Their use in the learning process is advantageous for several reasons: opening of new perspectives; providing a visualization of the abstract; provoking and motivating student's interest; taking student's prior knowledge into consideration and revealing misconceptions in areas already taught.[7] According to Bartha,[9] analogies have been widely and successfully employed throughout history to generate insight and formulate possible solutions to problems.

Meaningful learning consists of the integration of existing knowledge with new knowledge.[10] The teaching of color mixing occurs globally in primary education,[11] which makes it a familiar analog domain for almost all students worldwide. Furthermore, the recent pandemic crisis period affected society in several areas, including education,[12-14] with the interruption of presential academic activities and increasing demand for distance learning[12]. Hensen & Barbera[15] show that virtual activities might decrease student's emotional satisfaction and intellectual accessibility, however, it was also noted that teaching assistance may be more influential than specific locations. In this regard, visual appealing approaches are imperative in engaging students during remote or virtual lectures.

Here, we demonstrate with a class simulation, how familiar and relatively simple concepts such as colors composition can be used to introduce challenging and complex subjects such as isotope mixing models for undergraduate and graduate students.

Specifically, the objectives of the present paper are:

1) To present the analogy between the formation of colors and isotopic compositions[6] through the teaching with analogy (TWA) model, developed by Glynn[16] and modified by Harrison and Treagust[17];

2) To display examples of the analogy to explain source mixing isotope models for (post)transition metal pollutants (i.e Cu, Zn and Pb);

3) To propose an interactive activity with worksheets that are provided as supplementary materials.

4) To present a video, with a brief explanation of the didactic strategy

## METHODOLOGY

### Definitions and Considerations on Color Mixing Models

Before addressing the analogy, it is important to consider the color mixing model selected as the analog domain. There are two types of color synthesis phenomena: additive and subtractive. The additive synthesis regards the mixture of light, while the subtractive synthesis phenomenon occurs in the mixing of opaque coloring substances.[18] The RYB model (red, yellow and blue) is widely used in primary education, so that many people worldwide are familiar with it since early childhood. Therefore, the present work is based on the RYB system of primary colors and subtractive pigment synthesis. Note that the colors presented in the figures of this work, as in the case of any graphic presentation in computer monitors, television, and video projectors, are formed by the additive synthesis, even though they intend to represent the subtractive synthesis. According to Mauricio et al.,[11] there is no need to consider the wave-like aspects of light in teaching-learning about basic aspects of color.

To standardize the understanding of the concepts here presented, the following definitions, given by Pedrosa,[18] are adopted:

- Primary color: one of three non-component colors (red, yellow and blue) that, mixed in variable proportions, produce the rest of the colors in the spectrum.
- Secondary color: color (orange, green and purple) formed in optical balance by two primary colors.
- Tertiary color: intermediate color between a secondary color and any of the two primary colors that formed it.

## Isotopic notation basics

Isotopic variations of stable elements are reported as delta (δ), which is a relative value compared to a standard:

$$\delta^{i/j}E = \frac{\left(\frac{^{i}E}{^{j}E}\right) sample}{\left(\frac{^{i}E}{^{j}E}\right) standard} - 1$$

Where *i* and *j* represent the heavier and lighter isotopes of an element E, respectively. Stable isotopic ratios are expressed with the heavier isotope in the numerator and the lighter isotope in the denominator. Positive and negative δ-values indicate, respectively, enrichment and depletion in the heavier isotope relative to an internationally recognized standard. Isotopic variations of stable elements in nature are exceedingly small, so δ-values are usually expressed in *permil* by multiplying $\delta^{i/j}E$ by 1000 and adding the symbol (‰).

## Representation of the Analogy

Figure 1 presents a general abstract presentation of the analogy, based on Glynn[10] showing the superordinate concept that encompasses the analog and target domains, the features of these domains and how they are comparable with one another.

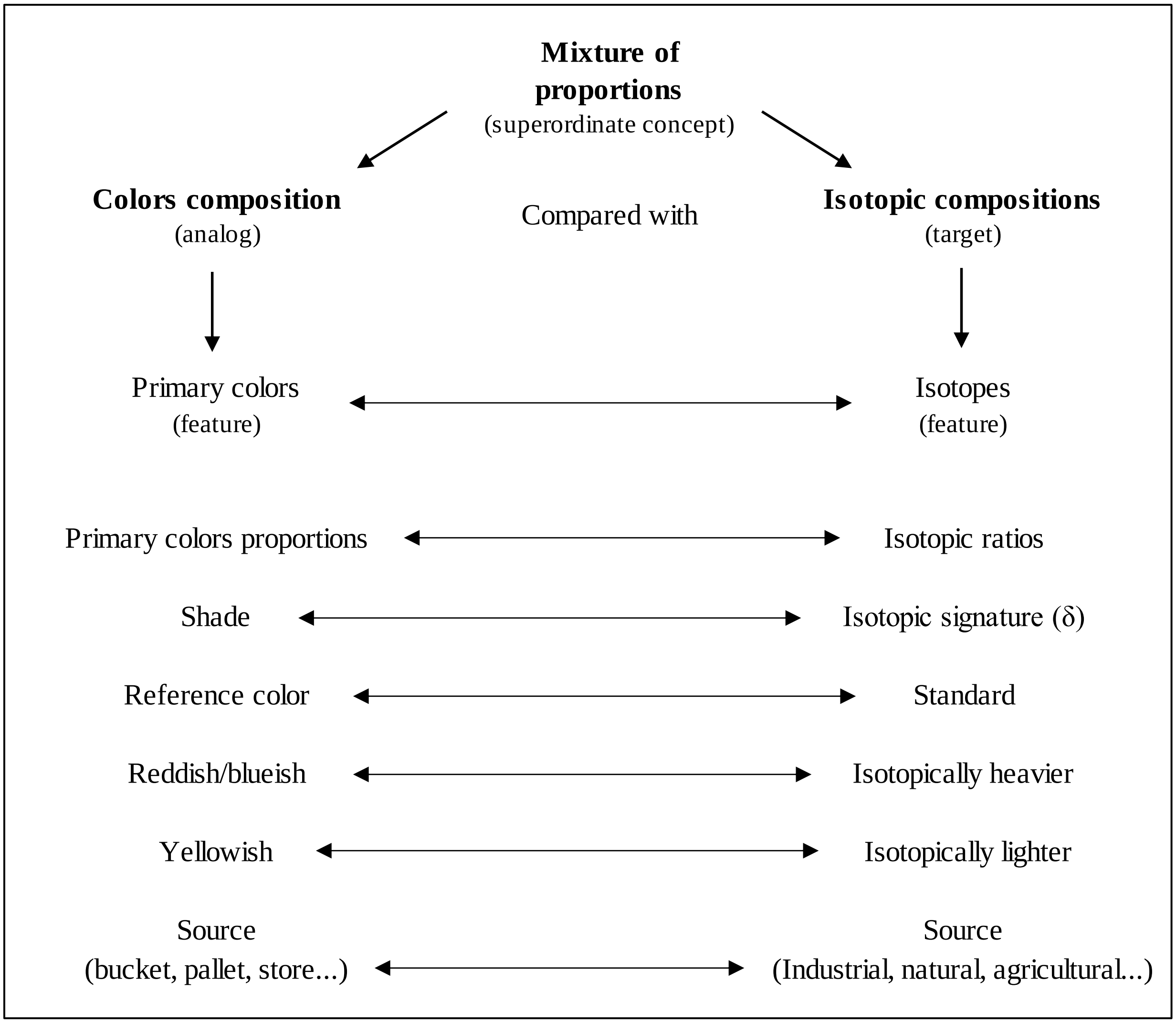


Figure 1. Schematic representation of the analogy based on Glynn[10].

In the present study, we simulate a class that presents the analogy (Figure 1). The class plan is based on the steps comprised by the TWA model, developed by Glynn[16] and modified by Harrison and Treagust.[17] This model provides guidelines for constructing analogies systematically and using them strategically to explain important concepts in ways that are meaningful to students, encompassing the following steps:

- Introduce the target concept.
- Cue the student's memory of the analogous situation.
- Identify the relevant features of the analog.
- Map the similarities between the analog and the target concepts.
- Draw conclusions about the target concepts.

- Identify the comparisons for which the analogy breaks down.

After the presentation of the analogy, some examples of its applicability are provided. During each of these examples, analog features are visually and numerically explored through the presentation of a hypothetical situation, with the aim of enhancing the understanding of the visual and numerical features of a real source mixing isotope model.

The intention is not to restrict the usage of the analogy proposed by Fry[6] to the hypothetical situations provided in the simulated class, but to generate insight so that new proposals of approach can emerge that are appropriate in differentiating cultural scenarios in which the analogy is to be applied. Adapting these situations to the local cultural contexts is important to enhance interest, engagement and understanding. To demonstrate, the examples presented here will be contextualized with Brazilian culture.

## CLASS SIMULATION

### Step 1 – Introducing the target concept

During the introduction of the target concept, it is important to highlight its importance or some of its applicability, drawing the students' attention and, therefore, enhancing understanding.

> "Today we are going to learn about source mixing isotope models. In environmental studies, isotopic compositions provide important perspectives on tracing the source and circulation of, for instance, metal pollutants."

### Step 2 – Cue the students' memory of the analogous situation

> "Before addressing this thematic, I (teacher) would like you (students) to recall the formation of colors from primary color mixes. Here, the term color refers to the pigment-color stimulus, which is the material substance that absorbs and reflects the luminous rays' components of the light that diffuses over it."

Even though the analog domain is well known, it might be important to highlight some of its main characteristics and to attempt to the possibility of forgetfulness and root misconceptions, preventing them to be carried over to the analogy. The differentiation between pigment-color to light-color stimulus[16] is particularly important, considering that their mixing models are different. Additionally, Mauricio et al.[10] reported general misconceptions on color learning from elementary students, indicating that the Aristotelian conception that colors are an inherent property of material prevails.

### Step 3 – Identify the relevant features of the analog

> "For example, the secondary color orange is formed by the optical balance of red plus yellow. Depending on the proportions of primary colors used, orange will present different shades. The greater the proportional amount of red paint used in the mixture, the more reddish the resulting shade of orange will be. In the opposite direction, the smaller the proportional amount of red used in the mixture, the more yellowish the resulting shade of orange will be. Note that "yellowish" and "reddish" are expressions related to a reference, the secondary color orange."

### Step 4 – Map the similarities between the analog and the target concept

> "Similar to colors compositions, specific elemental isotopic compositions are formed by the sum of its isotopes. For example, in nature, copper has only two stable isotopes, $^{65}Cu$ and $^{63}Cu$, in a proportion of 30.85% and 69.17%, respectively. Heavier isotopic compositions indicate greater proportional amounts of $^{65}Cu$, while lighter isotopic compositions indicate greater proportional amounts of $^{63}Cu$. As for "yellowish" and "reddish", "heavier" and "lighter" are also expressions in relation to a reference, or, more appropriately in this case, to an internationally recognized standard"

Note that the analogy presented above is sufficient to introduce the target domain of isotopic compositions and some of its features, without necessarily requiring visual examples or numerical interpretations. These will be given afterwards to explore the potentiality of the analogy for understanding more complex issues regarding source mixing isotope models.

### Step 5 – Draw conclusions about the target concept

> "By observing a certain pigment, whether in a work of art, a wall, or a product, we can estimate the proportion of primary colors that formed it. Additionally, we can also estimate the contribution from sources. For example, for a wall colored with fresh yellowish orange paint, next to which there are buckets of green, yellow, and orange paint, it is intuitive and reasonable to think that the last two are the sources. Depending on the shade of the orange in the wall, we can even estimate the proportion of the contribution from each of the last two buckets. As occurs for pigment mixing, if we know the isotopic ratios of elements in the different environmental samples and potential sources, we can estimate the contribution from each."

Hewitt[19] draws some of the main conclusions for students about both the target concept and the analog, as we do here, even though the TWA model only suggests conclusions about the target concept (Step 5). Glynn,[10] who created the TWA model[16], highlights Hewitt[19] as exemplary in the usage of analogies.

### Step 6 – Identify the comparisons how the analogy is broken down.

> "There are only three primary colors: red, yellow and blue. Some isotopic systems have more than three natural isotopes, as is the case for Pb, Zn, among others, so that it would not be possible to represent each isotope with a primary color. Additionally, variations in isotopic ratios normally occur on exceedingly small scales, on the order of $10^{-3}$ to $10^{-4}$. Within the analogous system of paint mixture, these variations would approximately equate to the addition of a drop of yellow (~ 0.2 mL) to 100 mL of green paint, which would not present noticeable change of color"

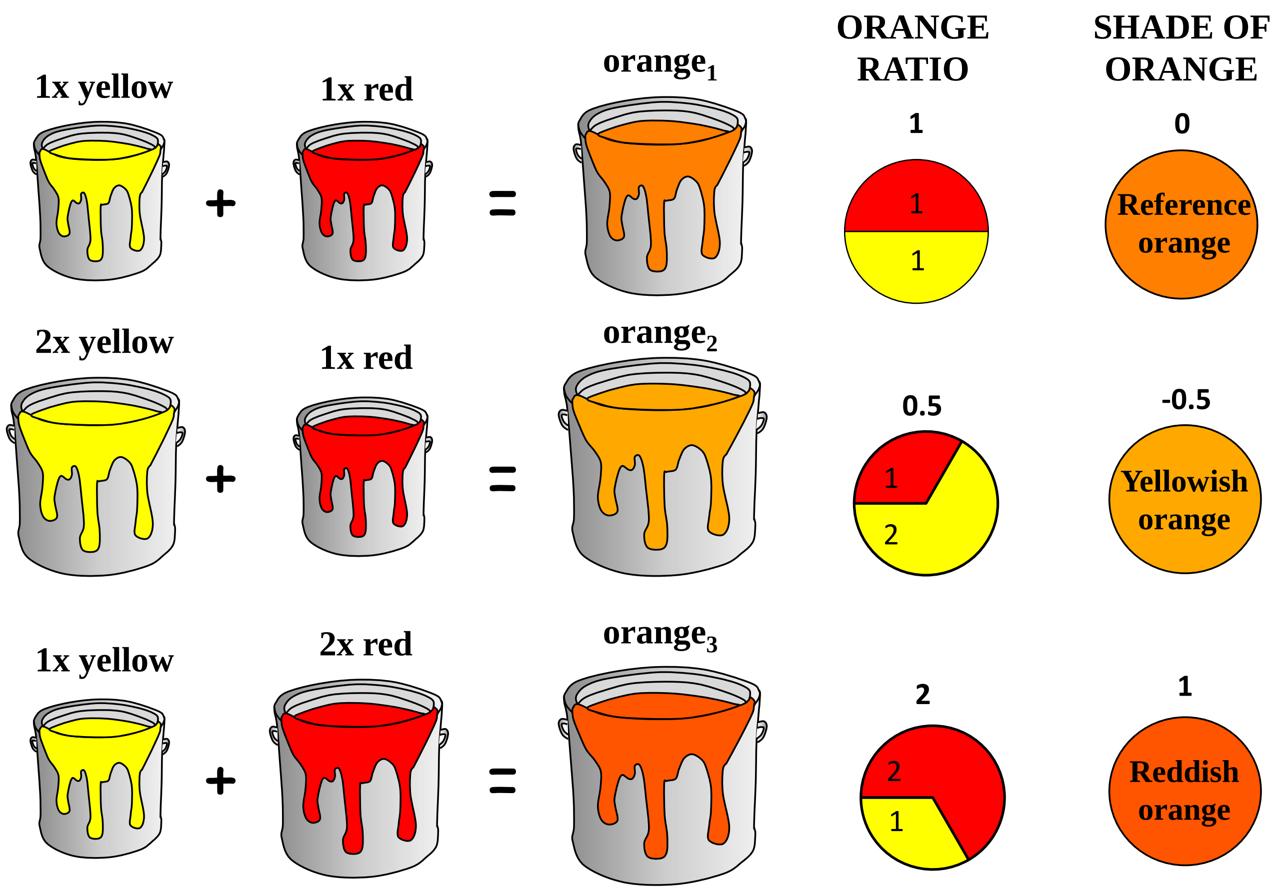
Hewitt[18], in his exemplary analogy between electrical and gravitational forces, is also faced with a limitation between scales. By means of a concrete example, he shows students that the electrical force is greater than the gravitational force, so much that the gravitational force is negligible. This is not an impediment for the analogy to be effective, as shown by Glynn.[10] Indeed, one of the advantages of using analogy is precisely to promote students' critical sense.

Additionally, as done by Hewitt[19], the presentation of the analogy's limitations can be given during the presentation of examples, without decreasing understanding, even if it does not strictly follow the TWA model sequence.

## Introducing the examples

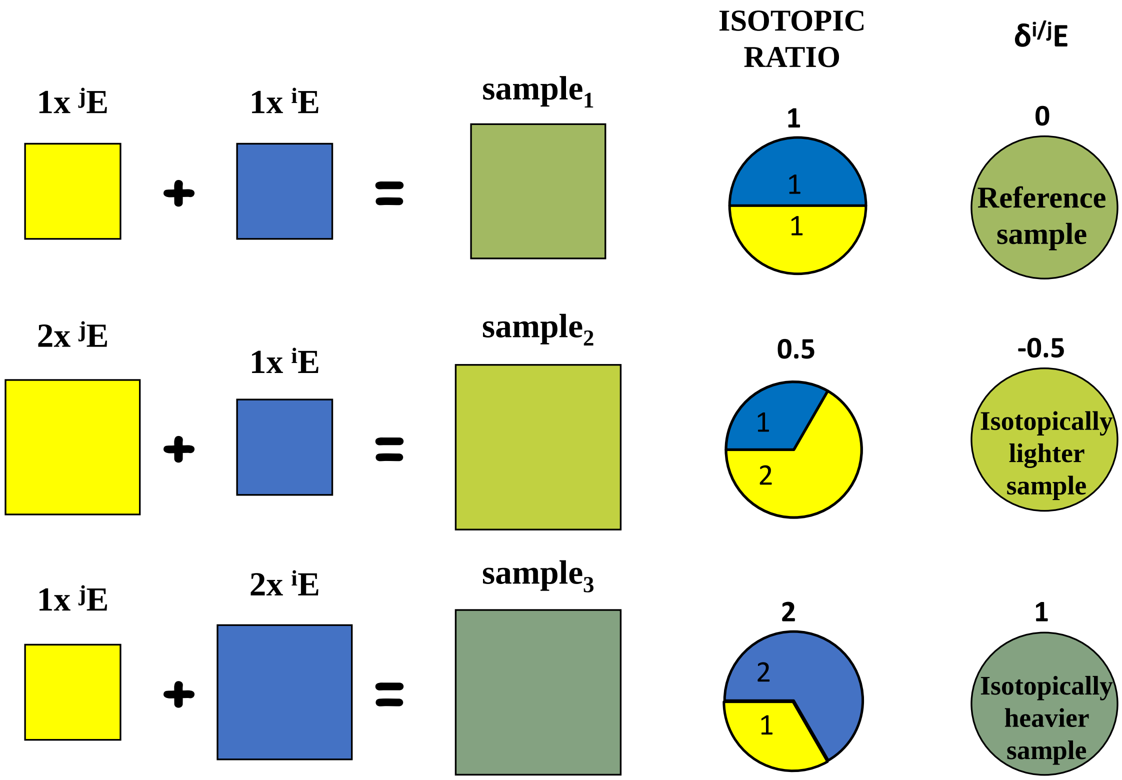
To illustrate the implications of the conclusions, this chapter provides examples, in which the analog and the target are explored in similar visual and numerical ways, so that understanding is favored.

"We can numerically express proportions of primary colors as color ratios. The resulting shades of orange can be expressed as colors ratios in relation to a reference ratio, as presented in Figure 2, so that positive and negative values indicate "reddish" and "yellowish" shades of orange, respectively. Just as suggested for "reddish" and "yellowish" shades, "heavier" and "lighter" isotopic compositions are numerically expressed in relation to a standard as δ (isotopic signature), so that positive and negative δ-values indicate isotopically heavier and lighter samples, as presented in Figure 3. Note that the isotopic ratios of standards are normally not equal to 1, as occurs for the example presented in Figure 2 with the aim of facilitating calculations. Also note that calculations using isotopic delta values are only meaningful for small variations of isotope ratios (*permil* level) and not extreme differences as shown in the example."




$$orange\ ratio = \frac{red}{yellow} \qquad Shade\ of\ orange = \frac{orange_x\ ratio}{orange_{reference}ratio} - 1$$

Figure 2 – Orange ratios and shades




$$Isotopic\ ratio = \frac{{}^{i}\mathrm{E}}{{}^{j}\mathrm{E}} \qquad \delta^{i/j}E = \frac{Isotopic\ ratio_{sample}}{Isotopic\ ratio_{standard}} - 1$$

Figure 3 – Isotopic ratios and signatures

## Example 1 – Zinc Isotope Mixing Model

> "We can estimate the color ratios and numerically express the shades of orange, for example, in the paint mixtures of a hypothetical Adrien Henri Vital Van Emelen's pallet, as shown in Figure 4. By comparing the paint mixtures in the pallet and the colors in each point of a work of art,[20] we can conjecture about the sources (paint mixtures in the pallet) from which proportions in specific combinations were used in the painting."

Here we assume, with a simplistic approximation to facilitate comprehension, that the selected orange tonalities of the painting are formed only by specific proportions of the primary colors red and yellow.

“By knowing the isotopic signatures of our samples and sources, we can also compare them and estimate the contributions in each case. Figure 5 highlights two superficial sedimentary samples from Sepetiba Bay (Rio de Janeiro, Brazil), in which Zn isotopic signatures were explained through a binary mixing model that includes a main anthropogenic source of contamination and natural sources.”[21]

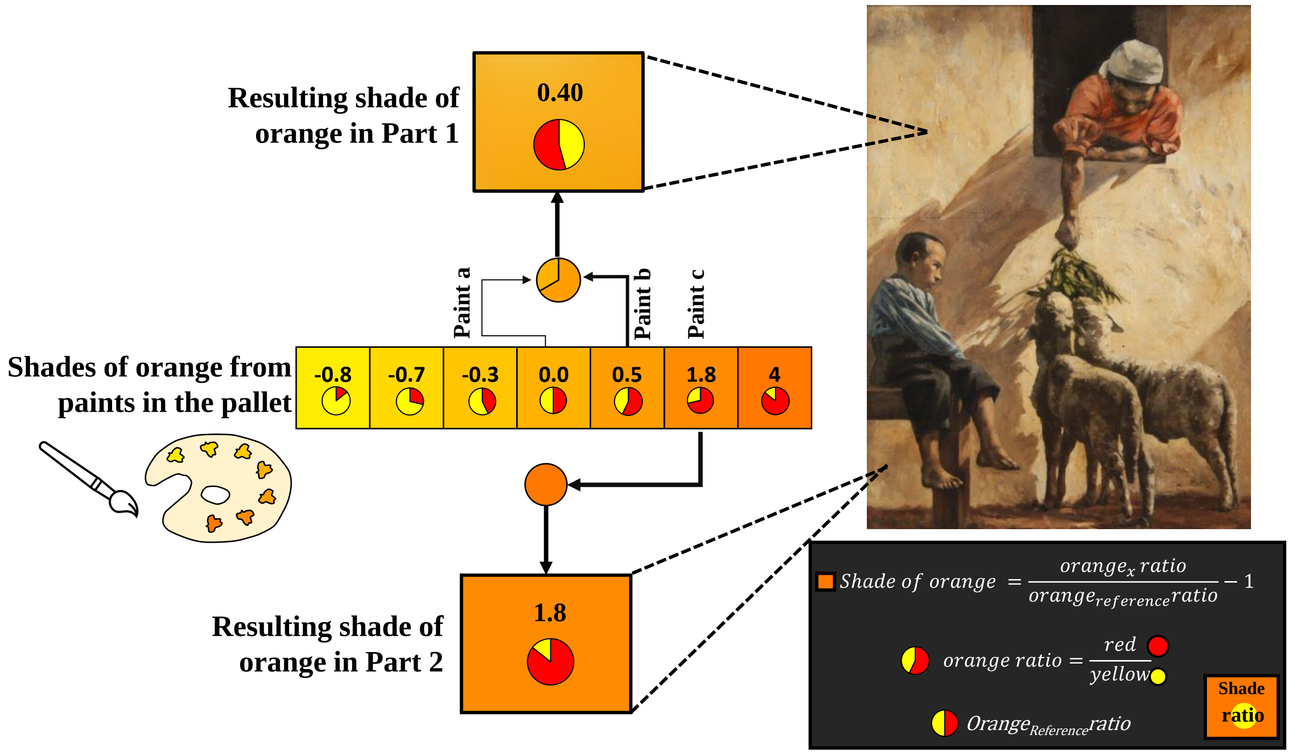



Figure 4 – Tracking sources of paint in Mulher na Janela Alimentando Cordeiros, Menino Sentado numa Banqueta, Adrien Henri Vital Van Emelen (1868–1943)[20]. Van Emelen, Adrien Henri Vital (1868–1943). Mulher na Janela Alimentando Cordeiros, Menino Sentado numa Banqueta, Brazil, 1-19717-0000-0000, Paulista Museum from the São Paulo University - USP. http://acervo.mp.usp.br (Aug 2021), licensed under CC-BY-4.0.

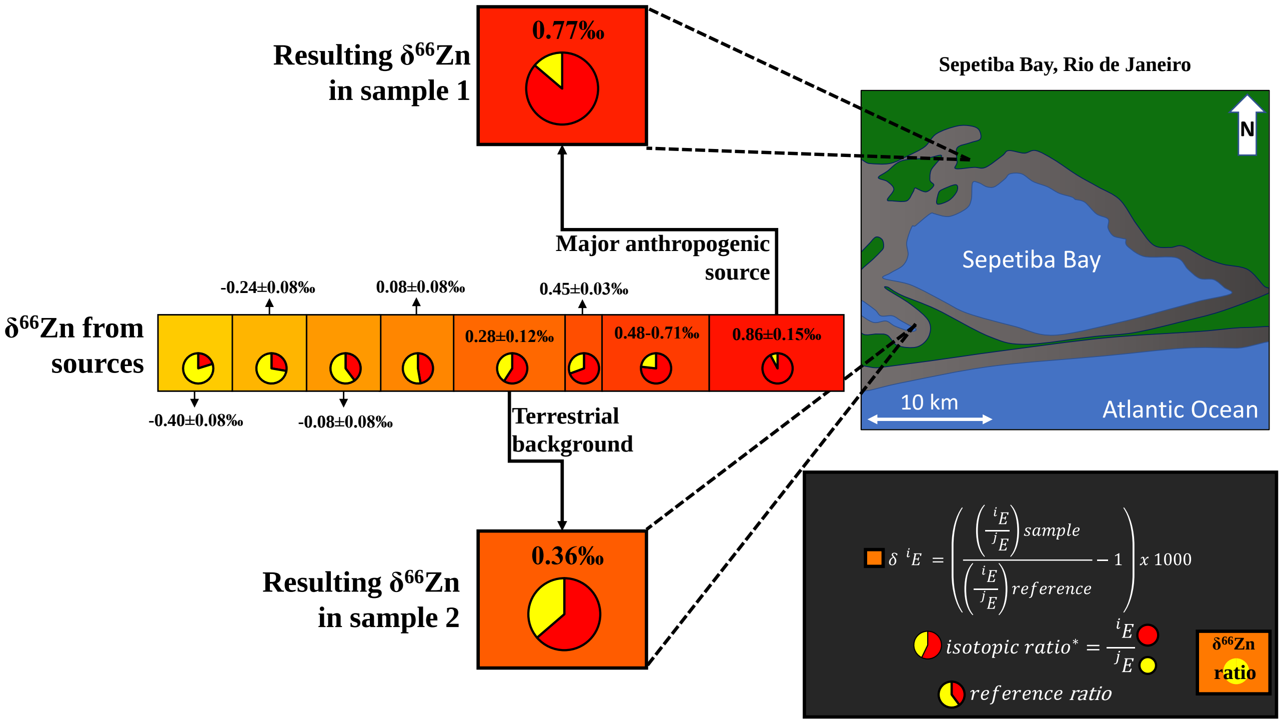



Figure 5 – Tracking sources of Zn in the Sepetiba Bay, based on Araújo et al.[21] $^{66}Zn$ and $^{64}Zn$ isotopes are represented by the color red and yellow, respectively. For this case, isotopic fractionation occurs in exceedingly small scales, of $10^{-3}$. For the pie charts (isotopic ratios) and tonalities ($\delta^{i}E$) to show visible changes, the isotopic shifts between the standard and the isotopic ratios were multiplied by 1000.

As detected in Step 6 of the TWA model, the variations in the isotopic ratios of the Zn isotopic system occur on exceedingly small scales. Thus, for the pie charts (isotopic ratios) and tonalities ($\delta^{i/j}E$) to show visible changes in Figure 5, the isotopic shifts between the isotopic ratios and standard were multiplied by 1000. The use of other scales and mathematical modifications may or may not be necessary depending on the isotopic system addressed.

### Example 2 – Lead Isotope Mixing Model

> "Let us imagine now we are working with the three primary colors, yellow, red and blue, so that it is possible to build a two-dimensional graph where the proportions between yellow and red are disposed on the x axis, and the proportion between yellow and blue are disposed along y axis, as shown in Figure 6. Each color in the graph is composed by different proportions of the three primary colors. Let us also imagine that we know the paint stores near the room where Oscar Pereira da Silva created Caminho do Mar, Calçada de Lorena, 1826.[22]. We can speculate about the sources of paints, by identifying their colors in the graph and comparing them to points in the work of art. Some isotope mixing models, such as for Pb, are usually expressed in binary graphs, with one isotopic ratio depicted in each axis. Figure 7 presents two selected samples from a case of successfully tracing the contribution of anthropogenic and natural sources of Pb to sediments in the Beibu Golf, China."[23]

Note that, fortunately for this case, the variations in the isotopic ratios are big enough, so that the variations between tonalities are visible without the necessity of using mathematical modifications.

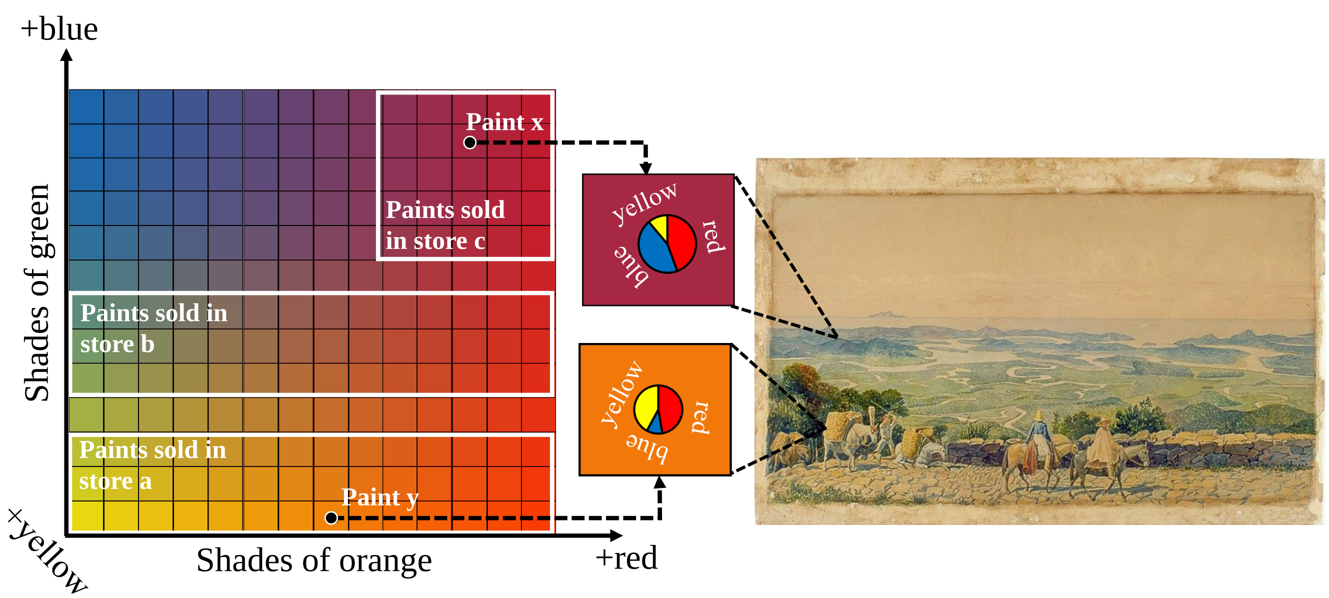



Figure 6 – Tracking sources of paint in Caminho do Mar, Calçada de Lorena, Oscar Pereira da Silva (1865–1939).[22] Source: Silva, Oscar Pereira da (1865–1939). Caminho do Mar, Calçada de Lorena, 1826, Brazil, 1-15174-0000-0000-02, Paulista Museum from the São Paulo University - USP. http://acervo.mp.usp.br (Aug 2021), licensed under CC-BY-4.0.

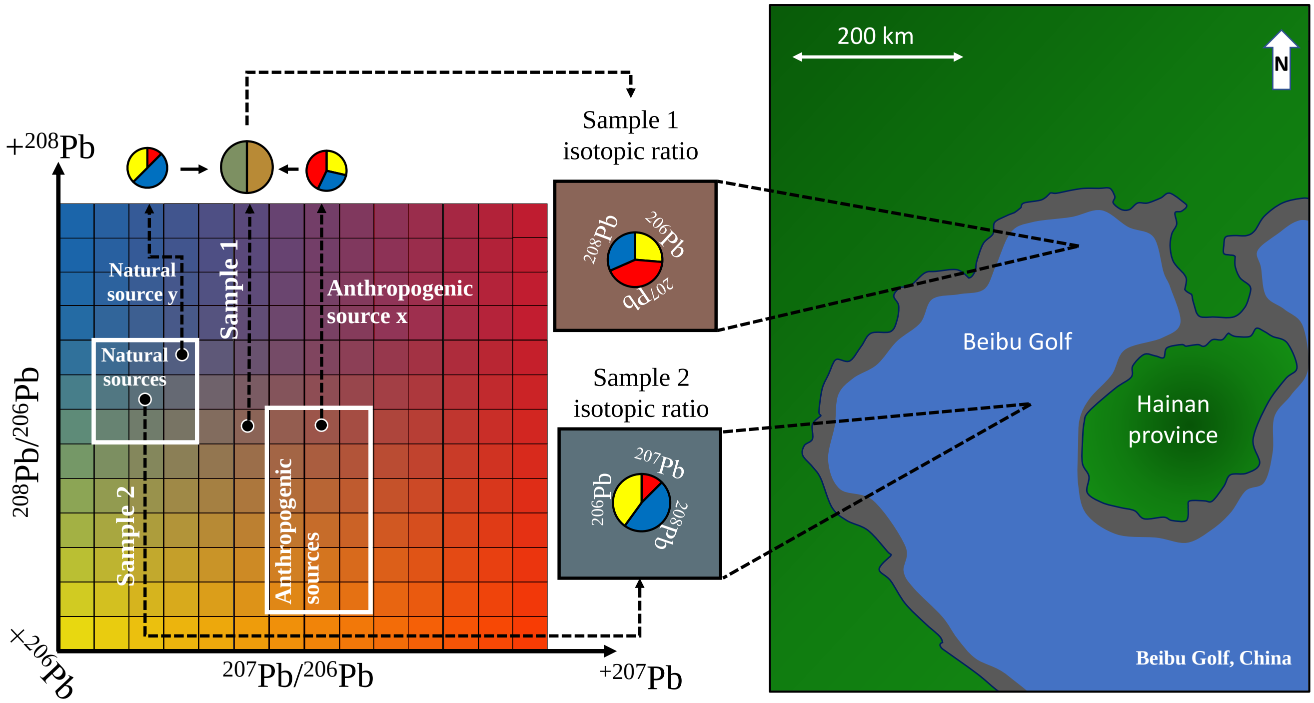



Figure 7 – Tracking sources of Pb in the Beiju Golf, based on Xu et al.[23] [19] $^{208}$Pb, $^{207}$Pb, and $^{206}$Pb isotopes are represented by the colors blue, red and yellow, respectively, so that Pb isotopic compositions in the graph are represented by a mixture of the three primary colors.

## Example 3 – Copper Isotope Mixing Model

"In addition to isotopic analyzes on surface samples, it is possible to perform them on greater depths with the aid of sedimentary cores. Have you ever heard about the bottles of colored sand, a typical craft from the state of Ceará (Brazi), named *ciclogravura*? They are manufactured by gradually applying aliquots of colored sand into bottles, filling it from the bottom to the top. In the same way, a sedimentary core is filled with sediments deposited from the bottom to the top along time. By observing the depth of the colored sands in a bottle, it is possible to reconstruct the relative time its application, as presented in Figure 8. In the same way, it is possible to reconstruct the history of contribution from sources through the isotopic analysis of a sedimentary core, as presented in Figure 9.[24] It is important to point out that, during the application of colored sands in the bottles, there is manipulation through a small tool used by the artisans, to detail the arrangement of the grains in the desired way. On the contrary, the deposition of sediments and subsequent bioturbations are natural occurrences. Also note, in Figure 9, the analytical uncertainty of the isotopic signatures and the similarities between the resulting shades of green in each depth. This raises a question about which isotope ratios and shades can be distinguished with a sufficient degree of certainty, or statistical significance."

Note that a new analogy is inserted here, between sedimentary cores (target) and *ciclogravura* (analogous), briefly following the steps proposed by the TWA model[16]. This analogy is added to the previous one, between isotopic and color mixing systems, so that the effectiveness of the latter is essential for effectiveness the former.

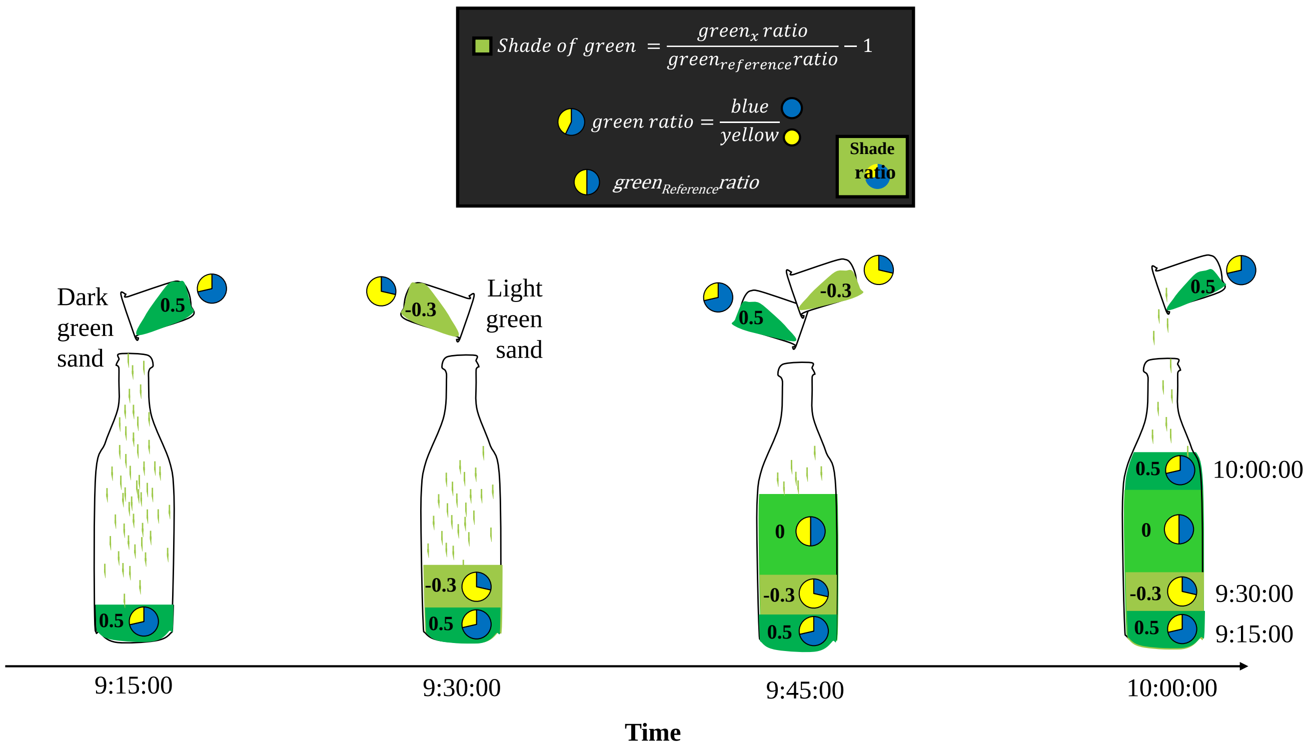



Figure 8 – Reconstructing the history of application of colored sands in Brazilian handicrafts.

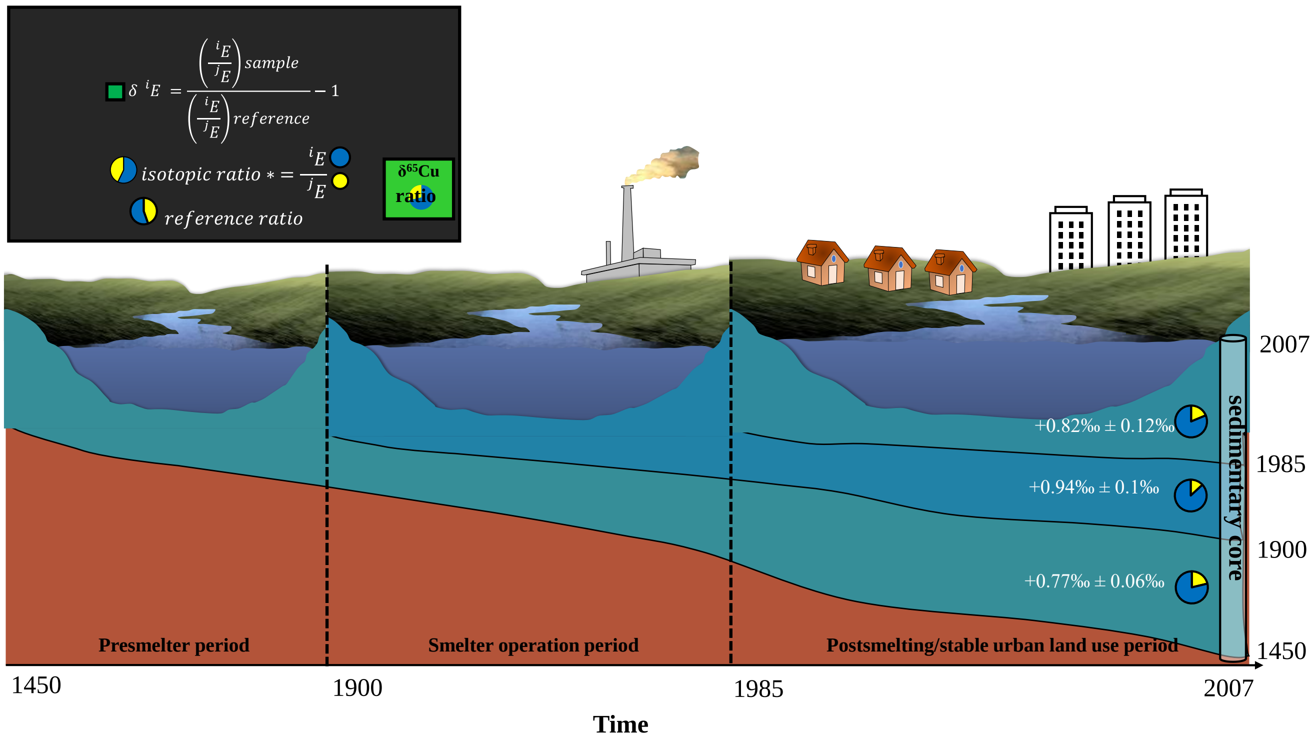



Figure 9 – Reconstructing the history of Cu contamination in lake sediments, based on Thapalia et al.[24] $^{65}Cu$ and $^{63}Cu$ isotopes are represented by the colors blue and yellow. For this case, isotopic fractionation occurs in exceedingly small scales, of $10^{-3}$. For the pie charts (isotopic ratios) and tonalities ($\delta^{i}E$) to show visible changes, the isotopic shifts between the standard and the isotopic ratios are in the scale of $10^{3}$.

## ASSESSMENT OF STUDENT SATISFACTION AND LEARNING OUTCOMES

The didactic approach outlined here was tested during remote teaching of the course 'Environmental Impact Assessment Methodology' (winter 2021, 18 students) and 'Environmental Contamination' (summer 2020, 18 students; and winter 2021, 20 students) within the Postgraduate Program in Geochemistry at the Fluminense Federal University (Rio de Janeiro, Brazil). Assessment of student satisfaction and learning outcome was done orally at the end of the course using well defined questions about student's perceptions and a specifically crafted spreadsheet. The oral and written feedback received was qualitatively representative, as 30 min at the end of the course were dedicated to student feedback and the students participated in an engaged manner in the questions we posed them.

The questions we asked the students to test student satisfaction and representative responses we received are described in Table 1:

**Table 1. Assessment of student satisfaction and course outcomes**

| Question | Typical Response |
|---|---|
| What did you like about the lecture? | "The approach was stimulating"<br>"The lecture kept my attention" |

| | |
|---|---|
| | "the course increased my interest in isotope chemistry"<br>"The strategy helped me fixing the content"<br>"I am stimulated to think about other didactic strategies within my area of expertise" |
| What were your main difficulties? | Undergraduate students highlighted that "the topic is complex and rarely addressed in class" so that they would probably need "more classes addressing isotope chemistry the help them not forget the content" |
| What improvements did you make? | "The difference between isotopic signatures and ratios is clearer after the lecture"<br>"The strategy helped me in address previous misconceptions regarding the difference between "isotopically lighter" and "isotopically heavier"."<br>"The approach improved my ability in the visualization and interpretation of isotope chemistry" |

To reinforce the analogy between isotopes and colors composition and assess the student outcome, a worksheet provided in the supplemental materials was used for interactive activity following the on-line lecture. The use of worksheets provides increased engagement and understanding. As the examples presented during the simulated lesson, the worksheet has two sections, one for colors and one for isotopes, designed in similar visual ways. Each section has white cells for data input, which can be freely filled in by students, and output cells with conditional visual formatting, which responds to the inputs. For colors, for example, depending on the quantities of yellow and red entered, different proportions and shades of orange are displayed in the output cells. The same happens in the section for isotopes, following therefore the analogy. Each section has five columns for experimentation, enabling comparisons between them. During this activity, the worksheet was filled out together with the students, testing different possibilities and discussing the outputs during. Students engaged and demonstrated that they understood the content of the lecture, to a large majority correctly answering questions asked and corroborating the positive outcomes orally provided by them.

## IMPLICATIONS

Since the mixing models are fundamentally part of isotope biogeochemistry, the use color mixing concepts can be widely thought as analogous domains, which is also facilitated by the fact that it is broadly familiar topic. A visual appealing approach, made possible by the analog, can increase the interest in target domains and enhance engaging in different areas of knowledge.

While we focused on the environmental issues, our approach can be extended to use isotope mixing models in a range of disciplines, including carbon cycling, magmas mixing, dietary sources, anthropology, archaeology and ecology for example.

Even though the present didactic approach is new, the functionalities of color schemes and color mixing are not. Colors are widely present in environmental and chemical sciences, such as in the elaboration of plumes of contamination, with the interpolation of elements concentration with colors gradient in maps. The implications of the analogy made by Fry[6] and explored here point towards the possibility of the elaboration of colorful maps of isotopic compositions distribution interpolated through primary color gradients. The displaying of isotope data in colorful maps has already been successfully presented, for example, in the isoscapes of Bowen (2010),[25] spatiotemporal distributions of isotopes in the environment, modelled with isotope fractionating processes and data describing environmental conditions.

We expect that the ideas presented here may stimulate teachers and students in thinking about other analogies and didactic strategies within the isotopic field. As pointed out by Glynn et al.[10] teachers and scientists should try to suggest other analogs to students, because each analog has its corresponding and noncorresponding features, and some will be better for some purposes than others. For instance, instead of isotopes, illustrating endmembers as primary colors might be useful, since it can eliminate the need for mathematical modification of isotopic shifts in some cases, and is a good alternative for working with multiple stable isotopes. Another good example of analogy within the isotopic field is Wiederhold's (2015),[26] between the mixing of two pools and a seesaw, illustrating the influence of pool sizes and isotope signatures on the resulting mixture.

Overall, the present study provides didactic material intended to introduce stable isotope mixing models to environmental sciences and chemistry students, which could be used both in classroom and remote classes, which is particularly advantageous considering the continuity of courses under the pandemic crisis.

A video with a brief explanation of the proposed didactic strategy can be accessed through the following QR-code in Figure 10:

Art, colors and isotopes

Figure 10 – QR-code of the YouTube video with a brief explanation of the proposed didactic strategy, presented by João Barreira. To access the video, point the camera of your mobile device at the QR code. Some mobile devices might need an app to scan QR codes.

## ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.XXXXXXX. [ACS will fill this in.]

Worksheet with the interactive activity bases on the analogy between colors and isotopes (XLS)

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