

Teratological changes in diatoms due to heavy metal stress

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Abstract

Heavy metal toxicity is a big hazard to water resources and is a regional problem for our four main areas of the planet. There are important benefits of bio associating contaminants using renewable sources such as microalgae. The diatoms are the most predominant and diverse phytoplankton community, representing 45% primary ocean productivity. In both fresh and marine water environments they have a ground-breaking impact in the biogeochemistry of metals. Diatoms are essential to degrade, detoxify and detoxify chemical waste and hazardous metals from contaminated sites. A diatom is primarily distinguished by the silicon-cell wall's unique ornamentation which is sustained and consistently replicated over generations. If the diatom cell outline and striation patterns will change, create teratological shapes, if subjected to various kinds of stress during reproductive processes. The goal of this review is to link abnormal morphology of the diatom cells to heavy metal stress with a view to greatly improving river assessment.

Keywords: Diatom, Heavy metal, Biomonitoring, Teratological changes

Introduction

Heavy metal pollution of water sources is a major problem that alters the structure and sustainability of aquatic habitats [1], as demonstrated by a drastic alteration of sensitive species replacement with resistant ones in the living biological populations of the affected fluvial habitats [2]. Heavy metal sources are natural or anthropogenic [3]. Heavier metals may either be weathered. In modern times, both human and industrial development has raised the concentrations of heavy metal in marine ecosystems, thus there is a risk of substantial metal emissions from human rush and deforestation [4]. In response to environmental factors, morphological changes in diatoms may be adaptive and non-adaptive. Teratological manifestations typically have a contour of valves or their striations. Non reversible phenotypical anomalies. Other modifications such as those with valve contours are transmitted mechanically during reproduction, which leads to a population with a morphological variation distinct from the parental population [5]. There appears to be a few groups of others, such as form and the distribution of striations. An abnormal outline of a valve is therefore more common than other teratologies [6]. There have been other kinds of aberrations, but they are more unusual. Many environmental stresses appear to be responsible for the development of teratological cells, as well as for the recording of abnormal cell in the diatom population or community. In aquatic environments the heavy-metal concentration is generally low; heavy metals "necessary" for each growth, photosynthesis, and breathing process are absorbed and used by diatoms for the construction of membranes and cell walls. The best possible ranges of concentrations of critical heavy metal for algal growth are typically low [7][3]. Even with low concentrations, the effects of heavy metals (for example, Hg, Cd, and Pb) are important, as they may affect the metabolic processes of the basic elements [8]. It has been shown that low levels of "non-" heavy metals may substitute or complement other "necessary" elements, for example Cd (or Co) can substitute for the Zn requirement [9]. On the other hand, 'non essentials' may sometimes increase biomass and metabolic processes of algae, as well as inhale secretory pathways [10][11] as for Hg²⁺ [3]. By both passive and active transportation mechanisms diatoms can adsorb dissolved heavy metals and their relative importance varies for each element. There have been plans for two major transport systems. A theory notes that metals interact in the combination of multivalent ion carriers or thiols with low molecular weight and eventually reach the cell by active transport (i.e. by transporters of amino acids) [12][13]. Heavy metals bind chelating proteins (for example, metallothioneins) and reach the cell via endocytose according to another hypothesis [13]. The absorption of the most cationic elements has been related to the concentration of free metal ions in the external medium and follows in general the pattern of absorptions. In addition, it is necessary to specify the chemical element and other ion or chelator [14]. However, once the heavy metals are within a cell, the membrane may become depolarized or cytoplasmic acidified leading to cellular homeostasis disturbance [13]. Heavy metals linked to proteins are at this time a complex of metal proteins that may impact enzyme systems, growth, photosynthesis, breathing, reproduction and nutrient assimilation as well as molecular synthesis [8]. Heavy metal reactions are closely related to the existence of tolerance mechanisms.

When high levels of heavy metals are not tolerated, algal growth is impaired and cells can die, but tolerances can be accumulated in and passed through the food chain in the cytoplasm.

For phytochelatin growth in marine phytoplankton, cadmium is the most important trace metal. Cadmium is capable of replacing cadmium in many metallozymes, because of its chemical resemblance to the basic heavy metals (for example, alkaline phosphatases, carbohydrases and dipeptidases), leading to functional inhibition. As cadmium is very similar to sulphhydryl groups, various major enzymes can be inactivated by these functional groups [15]. The absorption of silicon acid of diatoms, is regulated by sulphhydryl groups on the surface of cells which is why –SH binders evolve teratological forms. *Phaeodactylum tricorutum* is one of the most tolerant algae for heavy metal pollution; it synthesizes phytochalatins and tolerates high inner cadmium levels when metals in external medium exceed high levels [15]. Mechanisms for detoxifying can also be used in order to remove cytoplasm toxic elements [16]. The efflux of cadmium and phytochelatin from *Thalassiosira weissflogii*, the marine diatom, was led to high inorganic cadmium concentrations in water. Sicko-Goad & Stoermer [17] has shown that the Pb in *Fragilaria capucina*, *Stephanodiscus alpinus* and *S. niagarae* is produced in polyphosphate bodies. As Daniel & Chamberlain [18] demonstrated, in spherical polyphosphate systems found in vacuols, tolerant diatoms, like some species *Amphora* sp. and *Navicula* sp., can accumulate copper. In addition, the cytoplasmic fine structure may be influenced by the Cd, Cu, Hg, and Zn: electron dense inclusions were formed in the cell infected, multivesicular bodies and cytoplasmic tubules.

The most common cause of teratological forms are heavy metal pollution and artificial growth conditions. Cu, Cd and Zn tend in particular to be the most powerful trace metals in abnormal cell development. In *Fragilaria rumpens* and *F. tenera*, the copper led to the deformed valve contours. *Eunotia* sp. and *Eunotia exigua*, twinned valves in *Nitzschia delicatissima*, 90° rotation in *Asterionella formosa* frustules [19] and broad deformities in *A. jaonica*. No atypical decorative patterns have generally been reported. In *Achnanthisidium* spp., *Amphora pediculus*, *Eolimna minima*, *Gomphonema parvulum* and *Mayamaea* spp. the result was the development of an irregular valves contours (100 µg Cd·ℓ⁻¹) and *Nitzschia palea* [20]. Cadmium exposure has also caused *Tabellaria flocculosa* to form an uncommon colony. While there were no studies on Zn as the only pollutant, the combined Cd and Zn pollution was given considerable importance; these two heavy metals had an irregular valve and striation profile, a double central region and an irregular raphe canal in many species [21][22]. Such two heavy metals together caused irregular valve contours in *Fragilaria gracilis*, *Cocconeis pediculus* and *C. placentula*, in particular. The *Ulnaria ulna* was distinguished by an irregular striation pattern and displaced longitudinal region, while *Planothidium frequentissimum* showed the double central field, while *Nitzschia fonticola* presented a raphe canal in the same conditions.

A strong association between a valve size reduction and contamination by heavy metals has been shown for several studies and the occurrence of teratological types appears to be dependent on size. The amount of frustules with irregular striation increases since valves decrease in the length. Perhaps the connection between nuclear and cytoplasmic volume is the reason for this. The decrease in length in pennate diatoms contributes to decreased cell volume. Cell length changes are much greater than width changes, and the cells appear to have a circular outline. Typically, cytoplasmic and vacuolar volumes are decreasing, while the nuclear volume remains stable, thereby increasing the ratio of nuclear: cytoplasmic volumes.

Mercury is one of the most harmful heavy metals and can only withstand mercury contamination by the most resistant species. The abnormal structure of the colony in *Asterionella formosa* and abnormal morphology in *Nitzschia liebethrutti* occur together with mercury and tin. In Filvida River (Caima River Bassin), Portugal, a number of irregular valve production taxa have been identified. The presence in streams of sediment of high Cd and Zn levels tended to be correlated with the occurrence of teratological specimens of *Fragilaria crotonensis*, *Fragilaria capucina* var *rumpens*. These two metals, like copper, create asymmetric, irregular and bent frustules with incised valves [21]. In Riou Mort in south-western France, a significant positive correlation was identified between heavy metal (Cd and Zn) contamination and the presence of teratological forms [22]. In addition, in *Cocconeis pediculus*, *Cocconeis placentula* and *Planothidium frequentissimum*, morin [22] also found abnormal outline of valves among species belonging to the genera *Fragilaria* sp. and *Ulnaria* sp. Particularly *U. ulna* exhibited irregular striation patterns and displaced lengths. The combined presence of several elements is typically present in the atmosphere and artificial microcosms will be the only way of assessing cause-effect connection between metal and diatom. The mixed metal solution (As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Ge and Zn) could affect the formation of colonies according to Thomas et al. [23]. The frequency of aberrant chains increased as the concentration of Cu and Ge grew, while the components of the mixture were different. Study of the regression of dissolved metals in order to understand the existence

of irregular *fragilaria* cells revealed that the production of teratological forms has been carried out by Cd, Cu, Fe, and Zn.

Conclusion

Diatoms have been studied as an indicator of heavy metal contamination in wastewater. Diverse ecosystems have been affected by heavy metal pollution and are continuously deteriorating as a result of human intervention which leads to a deep interest in research into the identification of mechanisms and processes to address its harmful effects. Teratological types can be a reliable ecosystem health indicator. Upon determination of the causes and consequences of these anomalies, the individual state of diatom health becomes an important method for determining river water quality and measuring diatomic measures, in addition to diatom population composition. Diatoms are the best natural driven material with high commercial potential for adsorption of heavy metal. They are therefore potential candidates for heavy metal phytoremediation due to their ability to tolerate pollution and bioaccumulate heavy metals, requires further research.

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