Efficiency of CONAMA 454/12 ensuring the correct disposal of contaminated sediments: a review.

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Abstract. Dredging is the process of removing material from the bed of water bodies, with a specific purpose. This is a procedure commonly performed in harbor channels to maintain or increase flow capacity. For this reason, several legal instruments were created to regulate dredging processes in Brazilian territory, including Resolution No. 454/2012 of the National Council for the Environment (CONAMA). This resolution regulates the management methods for material that will be dredged in waters under national jurisdiction and its final disposal. The physical and chemical characterizations of the material to be dredged are of great importance for the assessment of its disposal, management and monitoring, observing the framework of the classification in the toxic effect thresholds (Level 1 and Level 2) established in the resolution. However, in its article 12, first paragraph, the legislation leaves to the discretion of the entrepreneur the choice of carrying out acute or chronic ecotoxicological tests to prove the toxicity of the sediment according to the chemical contamination. It is known that there is a difference in the sensitivity of these tests. The non-mandatory performance of chronic assays may interfere with the sensitivity aspects of the analysis, since many stressors may not demonstrate acute toxicity but indicate chronic toxicity. The present study evaluated 5 articles that performed acute and chronic tests to assess the sensitivity of ecotoxicological tests and relate the results to the efficiency of Brazilian legislation. It was observed that chronic tests have a significant effect on biota even when acute tests do not indicate environmental risk. This factor is decisive in the disposal of contaminated sediment and can generate harmful effects in new areas.

Keywords. CONAMA 454/12, Acute tests, Chronic tests, Contaminated sediments, dredging, ecotoxicology.

1. Introduction

Anthropogenic impacts are widely found in the marine environment and increasingly challenge the resilience of the ecosystems that comprise it [1]. One of the main causes of ecological changes in marine ecosystems is chemical pollution. The introduction of organic and inorganic elements into the aquatic environment directly impacts benthic habitats. Most of these contaminants are deposited in the sediment, associating with organic matter, causing this environment to present high concentrations of chemical substances [2]. Benthic biota are believed to make up 98% of marine species. Contamination in the sediment can affect its structural and functional connectivity [3]. Allied to the effects caused on the benthic fauna, some human activities, such as dredging, can cause the resuspension of the sediment in the water column. This increases the possibility of re-solubilizing the contaminants, compromising water quality and promoting its bioavailability [4].

DPC Ordinance No. 109 of 12/16/2003 defines dredging as “the act of removing material from the bed of water bodies, with a specific purpose”. This operation allows, among other actions, the deepening, widening and maintenance of the navigability of channels. In these regions, dredging is fundamental since the bottom tends to suffer from siltation due to hydrodynamics, which may impair the transit of ships [5]. Dredging activities produce a large volume of sediments to be removed and disposed of. Disposal is one of the main problems in managing the coastal zone, as much of this material is contaminated with different substances at different levels [6]. Many of the xenobiotics found have great potential for bioaccumulation and biomagnification, in addition to a high degree of

toxicity [5].

Contamination in sediments in Brazil is currently regulated by the Resolution of the National Council for the Environment (CONAMA) No. 454 of November 1, 2012. It establishes the main procedures for managing the material to be dredged in the national domain. The levels described were established through international studies that evaluated the relationship between dose and exposure time with the effects of xenobiotics [7]. Evaluation endpoints were determined, which are environmental values that must be protected [8]. However, the mere presence of the contaminant in the sediment cannot be considered to cause harmful effects. It is necessary to establish the relationship between the bioavailable concentration and the effects caused on the biota [8]. The use of acute exposure and chronic exposure allows searching for general trends, simplifying the complexity and variability of results [9].

Contamination of sediments in environments that have a mixture of harmful substances, as is the case in most port environments, has synergistic effects on the biota. Its characterization is important because often the deleterious effects, evaluated in chronic tests, take long periods of time to manifest, and may have surpassed the point of reversibility of corrective actions or risk reduction [8].

CONAMA 454, in its article 12, paragraph 1, states that the entrepreneur can choose to perform an acute or chronic test. In academia, it is known that chronic tests offer more sensitive results on the toxicity of contaminants in biota than acute tests. For this reason, the non-obligation to carry out the two ecotoxicological tests can influence the results, since the exposure time of the organisms to the contaminants present in the environment are directly related to the effects generated on their health [8]. Therefore, it is important that both chronic and acute tests are carried out on sediments to be dredged with proven chemical contamination, thus better understanding the environmental risks that can be generated after their disposal.

The objective of the present study was to evaluate the sensitivity of acute and chronic ecotoxicological tests applied in studies of contaminated sediments to be dredged and to qualify the efficiency of the application of CONAMA 454/2012 ensuring the correct disposal of contaminated sediments.

2. Materials and methods

From the definition of keywords, the databases to be used in the review were defined. The chosen database was Google Scholar. With a computer connected to the internet, the search site was accessed and a login was performed. The search was made from the combination of keywords and the use of logical operators. In the site's search bar, the following sentence was typed: ""CONAMA 454" + "acute tests" + "chronic tests"". The search was conducted in English to cover a greater number of results on the platform.

The first page of results was analyzed and articles of interest were saved on the Google Scholar platform. Subsequently, the articles were read and organized in a table according to abiotic components: contaminants and exposure time in days and biotic components: matrix (sediment, interstitial water and elutriate), test organism, observed effect and exposure time.

The bibliographic review was organized according to the checklist described in the PRISMA Method - Main Items for Reporting Systematic Reviews and Meta-analyses [10].

3. Results and discussion

The data collected on the effects caused by chemical contamination of the sediment on the organisms according to the exposure time were organized according to the type of ecotoxicological test (acute and chronic) (Table 1).

All articles in this bibliographic review used sediment samples collected in places with chemical control and contamination. The characterization of contaminant concentrations was performed on all samples prior to exposure of the organisms. Therefore, the works do not suggest parameters such as concentration of effect that induces 50% of the maximum effect (EC50) and concentration that causes lethality for 50% of exposed organisms (LC50), for example. The tests are carried out based on the concentration of contaminants already present in the environment and the contaminants of interest for the study are characterized. All articles worked with areas of saline/brackish water in accordance with CONAMA 454/2012.

Tab. 1 - Effects observed in acute and chronic tests according to exposure time and mixture of contaminants.

Test	Reference	Matrix	Organism	Observed effect	Exposure time (days)	Mixture of contaminants	Toxicity
Acute	[11]	Sediment	*Tiburonella viscana*	Survival rate	10	As, Hg, Pb,Zn, Dibenz[a,h]anthracene, Total PAHs, Total PCBS	No
	[12]	Sediment	*Tiburonella viscana*	Survival rate	10	Cd, Cu, Fe, Ni, Pb, Zn, Cr, CaCO3, Organic matter	No

	[13]	Sediment	*Tiburonella viscana*	Survival rate	10	Organic matter, CaCO3, Cd, Cu, Zn	Yes
	[14]	Sediment	*Tiburonella viscana*	Survival rate	10	Total PAHs, PCBs, Phthalates, Aldrin, Pb, Cu, Cr, Mn, Ni, Zn	No
	[15]	Sediment	*Tiburonella viscana*	Survival rate	10	PCBs, As, Cr, Cu, Hg, Ni, Pb, Zn	Yes
Chronic	[11]	Interstitial water and elutriate	*Lytechinus variegatus*	Growth rate	1	As, Hg, Pb,Zn, Dibenz[a,h]anthracene, Total PAHs, Total PCBS	Yes
	[12]	Sediment	*Nitocra sp*	Reproductio n	7	Cd, Cu, Fe, Ni, Pb, Zn, Cr, CaCO3, Organic matter	Yes
	[13]	Sediment	*Tisbe biminiensis*	Reproductio n	7	Organic matter, CaCO3, Cd, Cu, Zn	Yes
	[14]	Interstitial water and elutriate	*Lytechinus variegatus*	Growth rate	1	Total PAHs, PCBs, Phthalates, Aldrin, Pb, Cu, Cr, Mn, Ni, Zn	Yes
	[15]	Sediment	*Nitocra sp*	Reproductio n	10	PCBs, As, Cr, Cu, Hg, Ni, Pb, Zn	Yes

Environmental factors can change the results, such as the kinetics and sorption of contaminants in the sediment and biomagnification [9]. The characterization of the sediment is done according to the contaminants of interest and resources of the analysis laboratory. It is very unlikely that the characterization will be able to represent the real situation of the sediment, regarding the concentrations of all the contaminants present there. Finally, as it is a mixture of xenobiotics, it is not possible to associate the observed damage to a specific contaminant. Even if it presents an environmental concentration above that allowed by CONAMA 454/2012, the effect must be attributed to the total situation in which the organism was exposed.

Among the articles used for the literature review, only two had an effect on both the acute test and the chronic test. The others followed as expected, showing a significant observed effect only in the chronic tests. Effects on immunological parameters, for example, are usually manifested after chronic exposure [8]. In the case of histopathological damage, changes are perceived during acute exposure when the levels of contaminants are considered high and monitoring in chronic exposure must be carried out to detect the sublethal aspects of the changes [8]. Therefore, performing only the acute test on contaminated sediments does not significantly represent the environmental risk that can be derived from this material and does not guarantee correct disposal.

In addition to carrying out ecotoxicological tests, it is also important that monitoring is carried out, to evaluate the results of the measure taken and to verify compliance [8]. This monitoring is relevant since acute and chronic ecotoxicological tests may have effects that are not considered relevant or even have no effects at all, but may generate effects in other stages of life, called multigenerational effects, or in higher groups of the organism in the food web, such as for example bioaccumulation [8]. In addition, biogeochemical behavior and environmental factors such as changes in oxygen concentration in the aquatic environment can also influence the amount of contaminants absorbed by organisms [8].

4. Conclusion

The data presented in this work demonstrated that the chronic tests demonstrate greater sensitivity than the acute tests, allowing the observation of significant effects at higher levels of organization, and that they have greater ecological relevance.

With this, it is possible to conclude that the performance of acute and chronic tests to characterize the environmental risk of the contaminated sediment is necessary in the dredging processes. The non-mandatory performance of the tests may influence the incorrect disposal of sediments, contaminating other areas. Therefore, it is concluded that currently CONAMA 454/2012 does not guarantee the correct disposal of sediments with chemical contamination dredged in waters under national jurisdiction.

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