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Bivalves (Pelecypoda) used as bioindicators of pollution on different beaches in the Bay of Panama.

Bivalvos (Pelecypoda) usados como bioindicadores de contaminación en diferentes playas de la Bahía de Panamá.

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Abstract

In this study, we analyzed the role of bivalve species present on 10 beaches in the Bay of Panama as bioindicators of pollution. We evaluated the type of adaptation they exhibit (tolerant and less tolerant). To this end, we evaluated the correlation between the different collection sites and the species found at each site. A total of 108 species in 58 genera and 33 families of bivalves (Pelecypods) were recorded. Lima pacifica, a highly pollution-tolerant bivalve, was found on the beaches of Punta Paitilla and Naos Island. Other filter-feeding bivalves collected with high commercial value and widely consumed in our country included *Ostrea conchaphila, Agerostrea megodon, Crassostrea columbiensis, C. corteziensis, Saccostrea palmula*, and *Striostrea iridescens*, which were attached to the rocks on five beaches in the Bay of Panama. The similarity coefficients obtained between these beaches indicate that two of the beaches studied have the same structural configuration, favoring the adaptability of the species found there. This suggests that, if only those sites with a high abundance of pollution-tolerant species are considered, the hypothesis is supported that the closest sectors share a greater number of pollutant-resistant species and are likely to recover more quickly than those farther away. Meanwhile, beaches with species that are not very tolerant, when these species disappear, indicate the unfavorable conditions these coastal areas face for the prevalence of these species' populations.

Keywords: coastal zone, pollution, bay, tolerant Panama,

Resumen

En este estudio, hemos analizado el papel que desempeñan especies de bivalvos, presentes en 10 playas de la bahía de Panamá, como bioindicadores de contaminación. Mediante el tipo de adaptación que presentan (tolerantes y poco tolerantes); para eso se evalúo la correlación que existe

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entre los diferentes puntos de recolecta y las especies encontradas en cada uno de ellos. Se registraron un total de 108 especies en 58 géneros y 33 familias de bivalvos (Pelecípodos). *Lima pacifica*, un bivalvo altamente tolerante a la contaminación, localizado en las playas de punta Paitilla e isla Naos; otros bivalvos filtradores recolectados de alto valor comercial y muy consumidas en nuestro país fueron la *Ostrea conchaphila*, *Agerostrea megodon*, *Crassostrea columbiensis*, *C. corteziensis*, *Saccostrea palmula* y *Striostrea iridescens*, estaban adheridos a las rocas de cinco playas de bahía de Panamá. Los coeficientes de similitud, obtenidos entre estas playas, nos indican que dos de las playas estudiadas poseen la misma conformación estructural que favorecen la adaptabilidad de las especies encontradas en ellas. Deduciendo que, si se consideran únicamente aquellos sitios con gran riqueza de especies tolerantes a la contaminación, se apoya la hipótesis de que los sectores más cercanos entre sí comparten un mayor número de especies resistentes a los contaminantes y es probable que tiendan a recuperarse más rápido que los alejados entre sí; mientras que las playas que presentan especies poco tolerantes al desaparecer estas especies, nos indican las condiciones desfavorables que tienen estas zonas costeras para que prevalezcan las poblaciones de estas especies.

Palabras clave: bahía, contaminación, Panamá tolerantes, zona costera

INTRODUCTION

The combination of rapid population growth, industrialization, and urbanization are causes directly associated with water pollution (Courtemanch *et al.,* 1989). Initially, water quality was assessed using physicochemical data, primarily analyzing the short-term effects of pollution; however, since the beginning of the 20th century, biological methods for determining water quality have been widely developed in Europe, accelerating in the 1950s, with plant and animal responses being identified as direct evidence of pollution (Figueroa, 1999).

According to Dauvin *et al*. (2010) there are different techniques to evaluate the quality of water subjected to wastewater discharges, where the most used are those using physicochemical parameters and the use of biological indicators or bioindicators. Now, when designing monitoring studies for different types of pollutants in aquatic habitats, it is important to consider the bivalve populations present in the study area as bioindicator organisms (Page *et al*., 2005; Chec *et al*., 2008). A clear example is the mussel, an excellent bivalve for monitoring marine pollutants due to

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its very limited metabolism, its filter feeding, and its sedentary behavior (Soriano-Sanz *et al*., 2006).

It is well known that one of the public health hazards is the discharge of wastewater into coastal waters, both for those who consume bivalves and for people who bathe in these waters (Fernández *et al*., 1971; Wanke & Guerrant 1987). Feeding on these mollusks, whether raw or undercooked, has led to the emergence of enteric diseases in people across the world (Dsenclos, 1991). This is because these mollusks can filter up to 50 liters of water per day (Martinez *et al*., 1991). Viruses present in wastewater when consumed by bivalves pass through the gill mucosa and are carried by ciliary movements to the mouth and subsequently transported to the stomach. Although these viruses do not replicate in bivalves, they can be digested by enzymes and are usually transported by macrophages to the musculature or are excreted in bivalve feces (Campos, 1990, Martínez *et al*., 1991); this confirms that bivalves can biomagnified concentrations of both bacteria and viruses, thus increasing the chances of infection when consumed raw or undercooked.

For biomonitoring of water quality and determining the degree of water pollution, bivalve mollusks have almost always been used, due to their ability to accumulate different contaminants in their soft tissues, without any affectation to the organism (Hamza-Chaffai, 2014), now this is given by the type of feeding of them, since they are capable of filtering large volumes of water, which helps them retain both microorganisms and contaminants in their soft parts; according to Ghozzi *et al*. (2017) this characteristic is generally present in all shellfish, which are considered among the best biological indicators of the health status of marine ecosystems.

According to Arce *et al*., (2006), the use of bioindicators is being proposed as a new tool for understanding water quality because their use greatly simplifies field and laboratory activities, as their application depends on the identification and quantification of species based on interval-adjusted diversity indices that assess water quality. This is very important because the methodology is very simple, but it does not mean that traditional methods of physicochemical analysis will be displaced.

Responses to pollution can be observed in both individuals and populations and are manifested through changes in behavior and physiology, or simply tolerance and intolerance to pollution. Given the diverse responses of both individuals and populations, different groups of mollusks have been used as indicators of pollution, either due to the disappearance of the species (stenobiontic), the predominance of certain species (euribiontic), or due to their ability to accumulate contaminants, or through bioaccumulation processes throughout their life cycle (biomagnification) (Baqueiro-Cárdenas *et al*., 2007).

A fundamental role in the quality of a marine ecosystem lies with its waters, as they provide many benefits and are part of various activities for nearby populations. However, as they are overused, they are subject to numerous pressures that consequently diminish water quality and modify its natural properties (Vivas-Aguas *et al*., 2010). This quality is measured by biotic and abiotic factors using environmental parameters present in the water (Pomeroy *et al*., 2006). According to Vivas-Aguas (2011), this quality is determined by the presence of compounds foreign to the natural environment, the natural levels of certain substances, and resource use. Furthermore, the state of the water is subject to movement, anthropogenic activities, and natural processes (Posada *et al*., 2012).

In biological processes, water quality is a limiting factor because it depends on the organisms, populations, and habitats found in marine and coastal areas. This is why, according to Pomeroy *et al*. (2006), water quality is key to the overall health and viability of biotic communities. Although water quality is constantly being studied to determine the viability of the resource for specific uses, the focus is on how aquatic environments are affected by the discharge of pollutants resulting from human activities, especially from urban wastewater treatment (Aurazo, 2004).

The biological information generated from these so-called bioindicators does not replace physicochemical analyses, but it does reduce the cost of water quality analyses, according to Chapman (1996). Some organisms have a very wide tolerance range to the environmental

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conditions present in the habitat where they live, largely depending on the degree of pollution at the site (Whiton, 1975). Based on this concept, the use of bioindicators is an ecological technique based on measuring the diversity and presence or absence of specific organisms (De La Lanza *et al.,* 2000). which leads us to present in this article the importance of bivalves as alternative tools for the evaluation of water quality, and to demonstrate this we will use different criteria and definitions that are used by some authors who used different organisms as bioindicators of water quality.

MATERIALS AND METHODS

Sampling was carried out on foot, collecting bivalve specimens by hand, on ten beaches in the Bay of Panama between the coordinates of 8°35' and 9°01' North latitude and 78°10' and 80°28' West longitude (Juan Díaz, Panama La Vieja, San Francisco de la Caleta, Punta Paitilla, the Paitilla ramp, San Felipe Market, Santo Domingo, Las Bóvedas, Punta Calafate and Naos Island), due to the characteristics of this area, which is shallow throughout its extension to the continental shelf, where it deepens abruptly. It has a very open coastal configuration, with a predominant amount of mud on the bottom, sometimes bordered by rocks that are exposed at low tide. Wastewater, industrial wastewater, and water from the capital city's hospitals also flow into this section. Several rivers also flow into the area, such as the Matasnillo, a tributary heavily polluted by the large amount of waste dumped into it because of human activities.

RESULTS AND DISCUSSION

A total of 108 species in 58 genera and 33 families of bivalves (Pelecypods) were recorded; 39 species were used as food by residents. Due to the tolerance and adaptability of some species of this class of mollusks, they have been considered preferred organisms for monitoring the presence of pollutants and as indicators of water quality in ecosystems. One of the species collected was the Lima pacifica Bruguiere 1797, a highly pollution-tolerant bivalve found on the beaches of Punta Paitilla and Isla Naos, two areas comprised of rocky substrates, an ideal habitat for the adaptation of this species. According to Keen (1971), it likes to live under rocks for protection when the tide is low.

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Other filter-feeding bivalves are oysters, which are capable of ingesting suspended particles with high concentrations of pathogenic microorganisms, which can affect the health of those who consume them if prepared improperly, according to González et al. (2009). From this group, species of high commercial value and widely consumed in our country were collected, such as *Ostrea conchaphila* Carpenter 1857, *Agerostrea megodon* (Hanley 1846), *Crassostrea columbiensis* Hanley 1846, *C. corteziensis* Hertlein 1951, *Saccostrea palmula* (Carpenter 1857), and *Striostrea iridescens* Hanley 1854, which were attached to the rocks of five beaches in the Bay of Panama. These organisms are efficient filter feeders and like to live on rocks, being exposed when the tide goes out and disappearing when the tide comes in. They are also highly sought-after organisms for the flavor of their flesh and their easy preparation for consumption.

Baquero-Cárdenas *et al*. (2007), the determination of contaminants in mollusk tissues is an indisputable indicator of their presence in the environment, particularly when their concentrations are not constant or are very high in the water, making it difficult to determine the actual values. Likewise, the decrease in reproductive potential, physiological state and population condition index are indicators of the presence of contaminants; moreover, it has been shown that the accumulation of contaminants is selective, making it impossible to determine their concentrations in different mollusk's.

CONCLUSION

Data obtained from different bivalve species should be used as a reference for bioindicators, because a single population used as an indicator of the health of a body of water can be recording erroneous signals of water quality due to the increase in a species that is highly tolerant or adapted to pollution. Using the bivalve group as bioindicators of water pollution is also essential because they are a heterogeneous group in which various responses to different types of environmental pressures can be obtained. The sedentary lifestyle of most species makes spatial studies possible, thanks in large part to their long-life cycles.

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