EFFECT OF TEMPERATURE ON THE RATE OF CONCENTRATION OF FAECAL COLIFORMS IN MUSSELS

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Abstract

The effects of different temperatures (12°C, 18°C, 24°C) on the rate of concentration of faecal coliforms (FC) in mussels were studied in experimental conditions at different concentrations of FC in seawater. At low initial concentrations of FC in mussels the rate of FC concentration increased with concentration of FC in seawater and with changes of temperature toward optimum. As concentration of FC in mussels increased, the rate of FC concentration decreased more rapidly as the concentration of FC in seawater increased and as the temperature was closer to optimum. Maximum concentrations of FC observed in mussels (level-off concentrations) were the highest at minimum temperature (at which rates of FC concentration were the lowest), whereas concentration of FC in seawater had no effect on level-off concentrations of FC in bivalves.

Key words: bacteria, bivalves, temperature

Introduction

The problem of faecal pollution in the coastal seawater, present in urban centers, has an effect on the sanitary quality of organisms living in such areas. Being sessile organisms the bivalves are permanently present in a certain area, and can not avoid stress situations by active moving. The rate of concentration of food particles in bivalves undoubtedly depends on the rate of filtration of seawater (1,2), which is determined by a number of factors such as food concentrations, flow rate, size of bivalves or life cycles of bivalves (3,4,5). However, one of the most important environmental factors which control filtration rate in bivalves is temperature (2,4). High filtration rate does not always mean high concentration of food particles in shellfish because of its low concentration in seawater. Similarly, high concentration of food particles in seawater does not always mean its higher concentration in shellfish, because at high food concentration decrease filtration rate as well as feeding efficiency (decrease retention rate and increase rate of pseudofaeces production occurs). From a practical point of view the most important question should be which concentrations of faecal pollution indicators in shellfish could be expected in particular conditions. In this paper, the effect of temperature on the rate of concentration of faecal coliforms (FC) in mussels as well as level-off concentration of FC in dependence on temperature and FC concentrations in seawater were studied.

Material and methods

Mussels (*Mytilus galloprovincialis*) were taken from the shellfish gardens near Split, and were held at ambient temperature in the laboratory until use. The experiments were carried out in 30 l fiberglass trays containing 15 l of seawater with bivalves of uniform size (4-5 cm). Each tray was aerated and termostated at experimental temperature. Ambient temperatures were changed to temperature of experiments at the rate of 0.5°C per day. After the experimental temperatures were reached, the bivalves were allowed to acclimate for at least two days. In the experiments, three temperatures and three concentrations of FC in trays were combined, and each experimental combination was carried out in several replications (3-6). The numbers of FC in bivalves were checked every hour until they reached plateau. Temperatures used in experiments were 12°C (mean winter temperature), 24°C (mean summer temperature), and 18°C (the temperature between these two extremes). Concentrations of FC in experimental trays were 10-10^3 FC L^{-1} ("unpolluted" seawater), 10^3-10^5 FC L^{-1} (moderately polluted seawater), and 10^5-10^7 FC L^{-1} (high polluted seawater). The beginning concentrations of FC (concentrations in the moment when experiments started) were low and varied between 0 and 13 FC per gram of flesh.

Results and discussion

In all experiments the rates of FC concentration in bivalves were high at the beginning of the experiments, when the initial concentrations of FC in bivalves were low, and decreased as the concentration in bivalves increased. Finally, at certain concentration of FC in bivalves (level-off concentration), bivalves ceased to concentrate FC (rate of concentration; k = 0) (Tab.1). Neither, the temperature nor concentration of FC in seawater changed this pattern, but both influenced the values of concentration rate as well as the slope of its decrease.At low initial concentrations of FC in mussels, the rate of concentration increased with the temperature. As concentration of FC in mussels increased, the rates of FC concentration decreased more rapidly at the higher temperature. As a result, at certain concentration ("turning-point concentration") of FC in mussels, or its narrow range, the rates of FC concentrations in mussels were similar at all temperatures (Tab.1). As the FC concentration in mussels kept on growing the rate of concentration became inversely proportional with temperature. As a consequence, the lower temperature, the higher was the level-off concentration (which is the maximal concentration of FC present in mussels), and more time was needed to reach that concentration (Tab.1). The concentration of FC in seawater (in experimental trays) had no effect on the pattern of temperature effect. However, the values of concentration rate, slope of its decrease and "turning point concentration" (concentration of FC in mussels at which positive correlation between concentration rate and temperature turns into negative correlation) varied in dependence on concentration of FC in seawater. At low initial concentration of FC in mussels, the rate of concentration of FC in bivalves increased with their concentration in seawater. As concentration of FC in mussels increased, the rates of concentration decreased more rapidly at higher concentrations of FC in seawater (Tab.1). Thus, mussels needed more time to reach the level-off concentration (maximal concentration of FC present in bivalves), at which mussels stopped concentrating FC (k = 0). Finally, the increase of FC number in seawater was also accompanied with the decrease of "turning point concentration". Contrary to temperature, which affected the values of maximal concentration of FC observed in mussels (inverse relationship was found), level-off concentration of FC in mussels did not significantly differed in dependence on concentration of FC in seawater. However, level-off concentrations were reached earlier as concentration of FC in seawater increased.

Tab. 1. The effect of temperature on the rate of concentration of faecal coliforms (FC) in mussels at different concentrations of FC in seawater

[Linear regression statistics: x = logarithm of concentration of FC in mussels, y = rate of concentration of FC in mussels (hours), y-int (intercept) = rate of concentration of FC at initial concentration of FC in mussels, r2 = coefficient of determination; Level-off concentration = maximal concentration of FC present in mussels at which concentration rate is zero (k = 0); Time = time needed for mussels to reach maximum concentration of FC in their bodies; "TP" ("turning-point concentration") = concentration of FC in mussels at which positive correlation between concentration rate and temperature turns into negative correlation.

Conc. of FC in seawater	Temp (°C)	Linear regression statistics			Level-off conc. (log FC g^{-1}	Time (h)	"TP" conc. (log FC g^{-1}	k (h) at "TP"
		y-int	slope	r^2				
Low 10 - 10^3 FC 1^{-1}	12	1.35	- 0.42	0.87	3.25	5.54	2.13	0.48
	18	1.90	- 0.68	0.95	2.75	3.33		
	24	3.12	- 1.25	0.88	2.50	1.85		
Moderate 10^3 - 10^5 FC 1^{-1}	12	3.35	- 0.94	0.81	3.56	2.45	1.45	2.00
	18	4.00	- 1.37	0.98	2.92	1.68		
	24	4.99	- 2.08	0.98	2.40	1.11		
High 10^5 - 10^7 FC 1^{-1}	12	5.17	- 1.52	0.91	3.40	1.51	1.30	3.20
	18	5.88	- 2.09	0.87	2.82	1.10		
	24	7.48	- 3.25	0.91	2.30	0.71		

Our study showed that higher concentration of food particles as well as change of temperature toward optimum, increased the rate of bacterial concentration in bivalves. At the same time, as concentration of bacteria in bivalves increases, the concentration rate decreases more rapidly as the concentration of bacteria in seawater increases and as the temperature is closer to optimum. Therefore, in conditions which are closer to optimal, bivalves need less time to reach level-off concentrations of bacteria and to become inefficient in feeding (decrease retention rate and increase the rate of pseudofaeces production). Finally, due to the fact that bacteria are not only, and very probably not the most important food for bivalves, the rates of FC concentration, as well as the values of level-off concentration are primarily determined by concentration of particulate organic matter, detritus and other particles suspended in the surrounding water. Thus, the results of this study could be interesting rather as qualitative than quantitative model.

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