RADIOECOLOGY OF SOME BLUEGREEN ALGAE

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ABSTRACT

The bluegreen algae *Anacystis nidulans* and *Anabaena floa-aquae* absorb thorium by a passive process when the chemical is present in the medium. However, the two species differ significantly from each other in their capacity to absorb and accumulate the radiochemical, the effect of light on absorption, the highest concentration factor attained, etc., thereby showing that it is not safe to make generalised predictions about the reactions of any one radiochemical with regard to even closely related species of organisms.

INTRODUCTION

SINCE algae are among the most important primary producers in the hydrosphere, their uptake of radioactive elements is of considerable importance to man, as has been stressed by many[1-3]. Algae sometimes accumulate radioactive substances in their cells to concentrations several hundred times more than that present in the surrounding water[4-6], apparently for no special metabolic function[7]. By entering the food chains, these may cause serious hazards to man[1,8-9]. During an investigation into the effect of ionizing radiation of thorium on algae, it has been found that two species of the same group differ significantly in their capacity to absorb, accumulate and release the element. Thorium is of special interest because it is important in the nuclear energy field, as it can be transformed into fissile ^{233}U, and also because it is found in vast naturally-occurring radioactive deposits in several places on the Earth[10].

MATERIALS AND METHODS

Sterile cultures of the bluegreen algae *Anacystis nidulans* and *Anabaena flos-aquae* were grown in a slightly modified medium of Kratz and Myers[11-12] and in Allen and Arnon's medium[13] respectively. The cultures were prepared in such a manner to have, at the time of commencement of the experiment, 10 mg wet weight of algal cells per flask with 25 ml culture solution and were maintained at 15°–18° C under continuous fluorescent "white" light of 4,800 lux. Thorium was supplied to them in the form of thorium chloride aqueous solution with thorium concentrations of 0·5 mg, 1·0 mg, 1·5 mg, 2·0 mg, 2·5 mg, 5·0 mg, 7·5 mg, 10·0 mg, 15·0 mg, 20·0 mg and 25·0 mg per flask. Three such sets were prepared besides the control. After 2 hours they were washed and filtered through Millipore filter No. HAWP. 047·00, put into 10·0 ml of scintillating liquid and the counts determined using an ICN Tracerlab Scintillation Counter. Corrections for the slight quenching caused by the algal cells were determined with the help of a previously prepared graph. The experiments were performed thrice with *A. nidulans* and *A. flos-aquae* cultures separately, using three replicates for every concentration of thorium. From the readings obtained the amount and percentage of thorium absorbed and the concentration factor were calculated.

RESULTS AND DISCUSSION

The results from the experiment represented in Fig. 1 shows that the amount of thorium absorbed by *A. flos-aquae* is limited to about 1·7 mg thorium/10 mg wet weight of alga, irrespective of

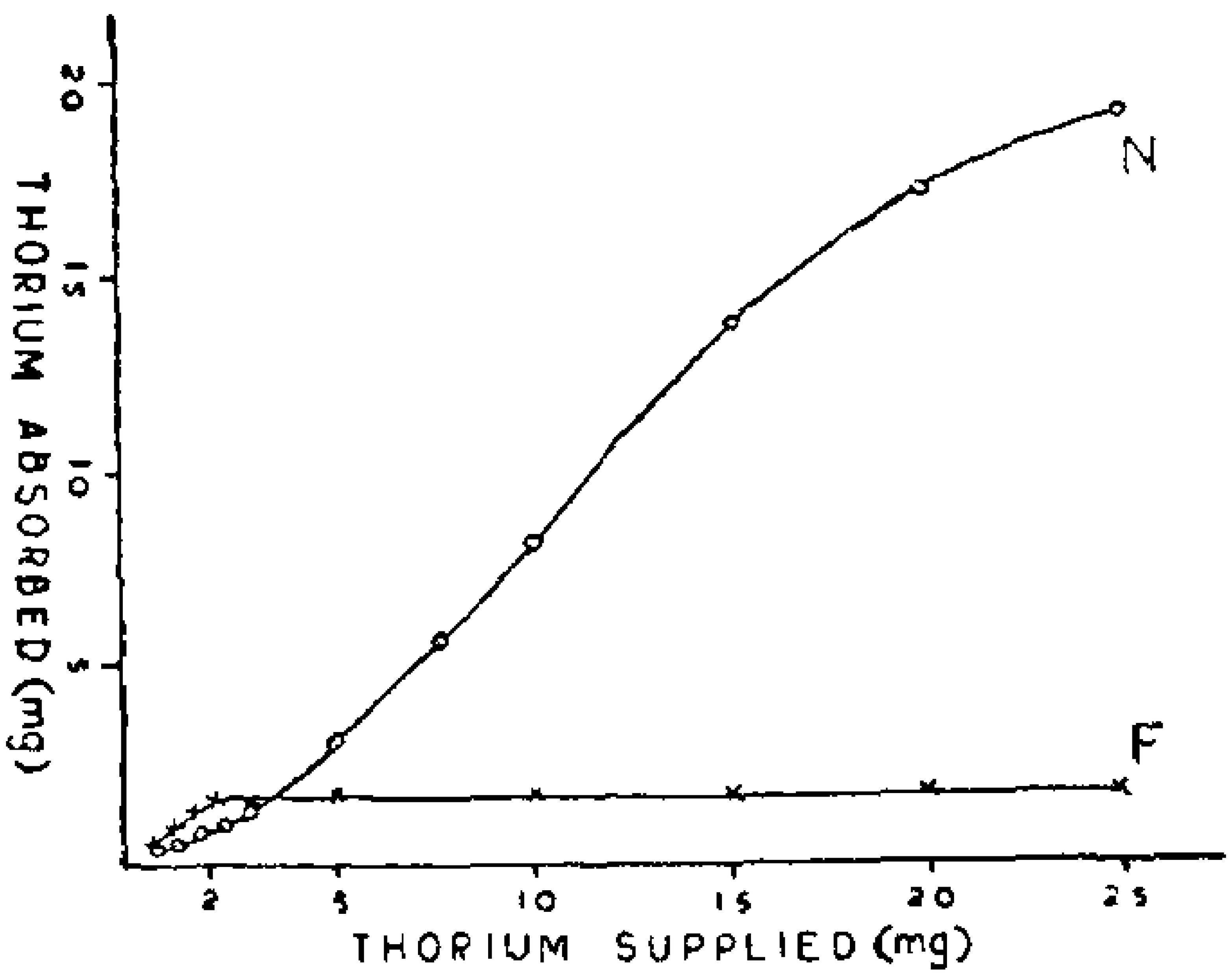

FIG. 1. The relation between concentration of thorium in the medium and the amount of thorium absorbed. (F = *Anabaena flos-aquae*; N = *Anacystis nidulans*.)

the increase in concentration of the chemical in the medium, while the capacity of *A nidulans* to absorb thorium increased correspondingly with its concentration in the medium. The maximum amount of thorium absorbed by *A. nidulans* is found to be about 19·6 mg/10 mg wet weight of alga.

With an increase in the concentration of thorium in the medium the concentration factor decreases in both the species. Moreover, while the rate of this decrease is slow in *A. nidulans* it is quite rapid in *A. flos-aquae* as shown in Fig. 2.

Although greater amounts of thorium are absorbed by *A. nidulans* at higher concentrations, the highest concentration factor of 8,248 was recorded in *A. flos-aquae* in comparison with the highest value of 6,540 in *A. nidulans*.

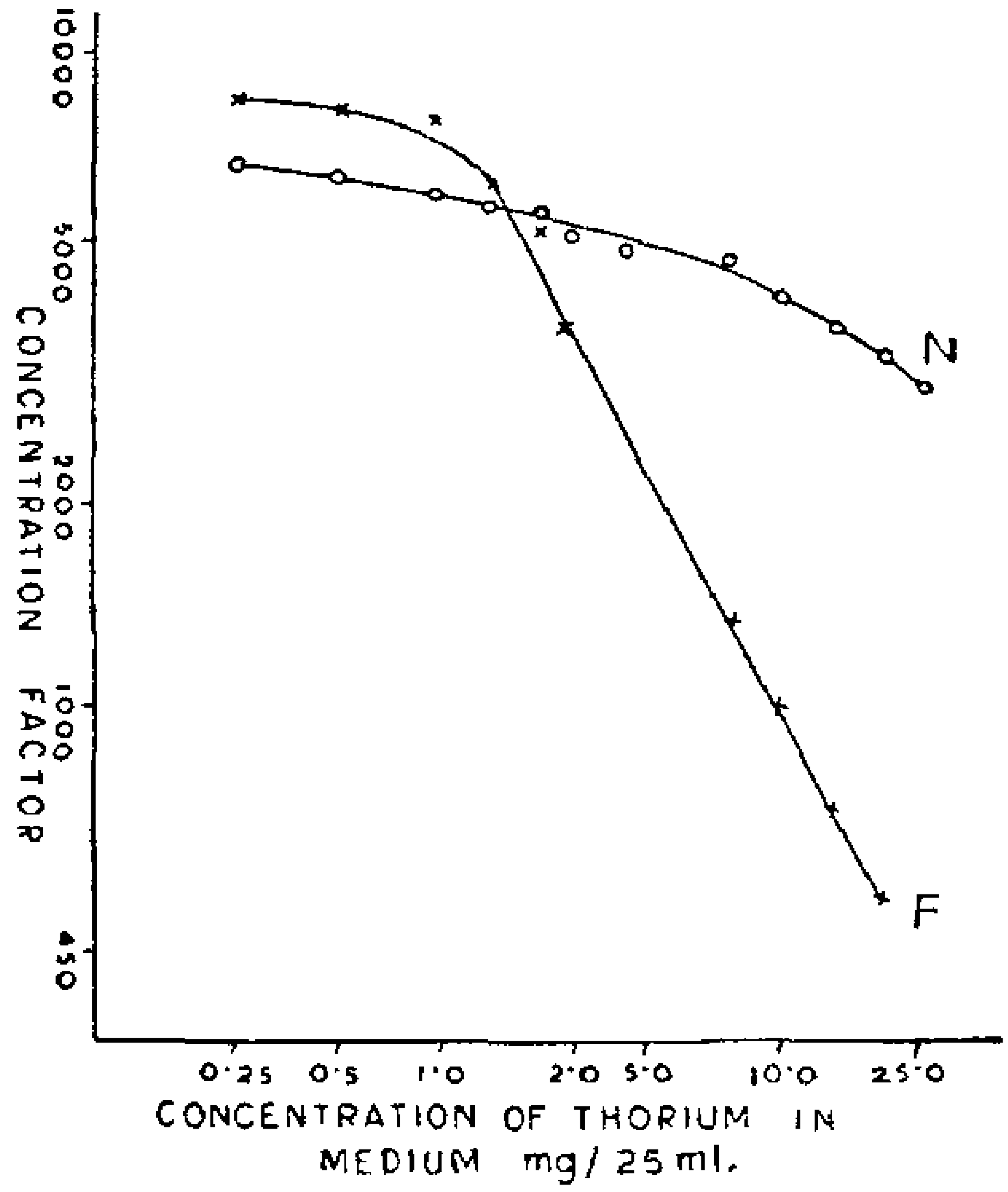

FIG. 2. The relation between concentration of thorium in the medium and the concentration factor. (F = *Anabaena flos-aquae* ; N = *Anacystis nidulans*.)

The absorption of thorium by both the species of bluegreen algae is by a passive process. The maximum concentration factor is attained in both species within 70 minutes of treatment with thorium. Contrary to expectation it has been found that in comparison with absorption, the quantity of the chemical adsorbed by the cells is negligible, being always below an average of 1·9%.

The sorption of some radiochemicals by dead cells, dividing cells and nondividing cells have been studied comparatively by some earlier investigators[14-15]. The pH of the medium is found to affect the absorption and retention of thorium by *A. flos-aquae* and *A. nidulans*. When the medium is made acidic with three drops of conc. H_2SO_4 per 25 ml of culture solution containing 10 mg wet weight of algae, 95%–97% of the absorbed thorium is released back into the medium by the cells within 5 minutes.

The uptake of radiochemicals such as strontium by marine algae is reported to be affected by light[16]. It is a common practice[1] that in terms of relation to light the radioactive substances are divided into two categories : (1) concentration depending on light and (2) concentration not depending on light. The results of an experiment with *A. nidulans* and *A. flos-aquae* grown in complete darkness and normal light, presented in Table I, reveals that light increases the rate of absorption of thorium to a small extent with *A. nidulans* but has no effect in the case of *A. flos-aquae*. This shows that the concentration of the radiochemical by the organism depends more upon the species concerned than on the presence or absence of light.

TABLE I

Comparison of concentration factor in cells grown in light and in darkness

Name of species	Concentration factor in cells grown in light	Concentration factor in cells grown in darkness
A. nidulans ..	4,902	4,430
A. flos-aquae ..	1,943	1,953

From the above experiments it becomes evident that it is not safe to make generalised predictions about the reactions of any one radiochemical with regard to even closely related species of organisms. This fact is important in the present context of increasing radiation pollution of the hydrosphere resulting from the production of radioactive wastes by the nuclear power industry and the radioactive fallout following nuclear weapon tests.

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ON THE POINT OF ORIGIN OF HEART BEAT IN THE SCORPION, *HETEROMETRUS FULVIPES* C. KOCH

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Introduction

In scorpions the heart beat is known to be neurogenic as evidenced by the presence of a cardiac ganglion and its spontaneous rhythmic burst activity related to the contractions of the heart muscle in 1 : 1 ratio[1,2]. Since the heart of the scorpion is tubular and the cardiac ganglion is on the mid-dorsal line of the heart, it is of interest to find whether the generation of the spontaneous impulses from the cardiac ganglion is simultaneous throughout the ganglion or spread from one region to the other in a regular sequence.

Previous work on scorpions showed that the heart beat is maximum in the posterior bits of the heart compared to those in the anterior bits[3,4]. Similarly alterations in the activity of the cardiac ganglion in the anterior and posterior parts have also been reported[3]. The present study is aimed at finding of such gradient activities in the heart beat and the cardiac ganglion in the scorpion are related.

Material and Methods

Hearts were isolated from the scorpions belonging to *Heterometrus fulvipes* C. Koch and maintained in the ringer medium[5]. Spontaneous electrical activity of the cardiac ganglion was studied by recording the electrical activity at different regions. The differences in characteristics like burst frequency, burst amplitude, burst duration and interburst intervals in the spontaneous electrical activity of the cardiac ganglion recorded at various levels were determined by analysing the recorded film.

Acetylcholinesterase (AChE) activity was determined in the two halves of the heart muscle based on the method of Metcalf[6]. Succinic dehydrogenase (SDH) activity was estimated by the application of the method described by Nachlas *et al.*[7]. Protein content of the heart muscle was estimated by the method of Lowry *et al.*[8] to represent the enzyme activities per milligram protein.

Results and Discussion

Earlier observations by the author[9] on the heart beat of the scorpion, *H. fulvipes*, indicated that there is a regular sequence in the cardiac cycle. The peristaltic wave commenced at the posterior part of the heart, and it gradually spread to the anterior end of the heart. The extent of contraction and relaxation of the heart decreased in the postero-anterior direction of the heart.

Recordings of the spontaneous electrical activity at different regions of the cardiac ganglion showed the presence of a postero-anterior gradient as in Fig. 1. The activity was maximum at the 7th ostial region of the cardiac ganglion and it gradually decreased anteriorly. As such, the activity was mostly in the form of regular bursts with few units firing in the interburst period at the posterior part of the ganglion. Such a typical burst of activity disappeared gradually towards the anterior end, especially at the 1st ostial region of the ganglion.

The characteristics of the burst also showed variation at different regions of the cardiac ganglion (Fig. 2). Burst frequency did not show any typical gradient and it was more or less fluctuating between 60–68 bursts/min (Fig. 2 *a*). The burst amplitude, however, showed a typical trend in that it decreased in the postero-anterior direction. It had a maximum burst amplitude value of 580 μ Volts at the 7th ostial region whereas the burst