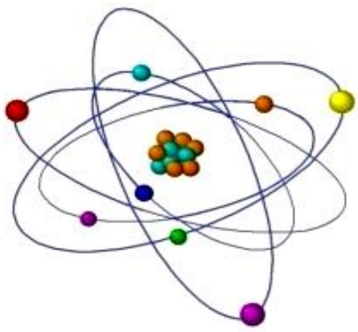
OPTICAL PROPERTIES OF STRONTIUM-SPIRULINA COMPLEXES AFTER CONTINUOUS HIGH DOSE IRRADIATION AND PARTIALLY MEDIUM MODIFICATION



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ABSTRACT*: Strontium is one of the most important radionuclides produced by nuclear fission. It enters the body through ingestion, inhalation, and skin and accumulates in tissues and organs. Therefore, it is of great importance to study the adsorption of radionuclides and heavy metals by Spirulina. It was studying the optical properties of Arthrospira platensis (spirulina) after partially replacing potassium ions with cesium ions ($K^+/Cs^+=2.5$ in medium) in nutrition medium, followed by irradiation 150 kGy with gamma radiation and re-cultivation. It was shown, that the action of strontium ions causes a change in the absorption intensity of spirulina. The addition of strontium after gamma irradiation and re-cultivation of spirulina results in a very rapid change in absorption intensity compared to the control, while the subsequent effect of strontium is almost negligible. Therefore, it can be assumed that in the case of irradiated spirulina, the first added strontium induces change that limits the action of subsequent strontium. Strontium causes a gradual decrease in absorption intensity for cases chlorophyll a, carotenoids, and C-phycocyanin in intact spirulina. Spirulina may serve as an effective biosorbent for reducing strontium.*

Key words: Spirulina *(Arthrospira platensis)*, Strontium, Gamma irradiation

INTRODUCTION

It is known, that between the most important fission produced radionuclides are strontium. The radioactive contaminants released during different accident includes cesium-137, strontium-90, i etc. [1]. Strontium -90 are produced from the nuclear fission of uranium and plutonium it accumulates in tissues and organs. After absorbed, Sr-90 absorbed into bones and teeth and may be cause cancer of bone [2]. The removal of radionuclides from body is required to prevent its accumulation in organs or tissues. The new technologies has drawn attention to algae based adsorbents that can remove radionuclides and toxic metals from the body [3].

Spirulina sp., due to its impressive chlorophyll contents, can effectively bind to heavy metals, chelating them, thereby facilitating their removal and detoxification from the body[4,5]. Cyanobacteria are Gram-negative prokaryotic organisms associated with detoxification, specifically the detoxification of toxic heavy metals. Intensive research on bioactive compounds from microalgae also proves their anticancer effects [6]. The natural blue colour is rarely found in food, making one of basic protein phycocyanin highly innovative in the food industry [7]. In [8] has highlighted the broad potentials of Spirulina for nutraceutical, therapeutic, pharmacological, energy related, and environmental applications. In [9] was envestiged to evaluate the adsorption and removal efficacy of spirulina for radionuclides viz., strontium (Sr), cesium (Cs) and etc. It was shown, that spirulina significantly reduced the wholebody retention of strontium and thallium. Pulverized Spirulina showed potential adsorption efficiency and may be used non-toxic agent for removal of strontium and thallium from body. Five grams of Spirulina a day given to children caused reduction of Cesium-137 in urine by 50% affected by Chernobyl radiation. Spirulina decreased radiation dose load received from food contamination with radionuclides [10].

By us in work were discussed effect of Cs(I) ions on irradiation 150 kGy and Zarouk's medium modification on spirulina [11]. In vivo removal efficacy of spirulina for strontium and other radionuclides is less known. In this paper was study the optical properties of *Arthrospira platensis* (spirulina) after partially replacing potassium ions with cesium ions (K^+/Cs^+=2.5 in medium) in nutrition medium, followed by irradiation 150 kGy with gamma radiation and re-cultivation.

MATERIALS AND METHODS

Blue-green algae spirulina, gamma irradiation, UV-VIS spectrometry, medium modification all is detailed discussed in work [11]. The same materials, conditions and technics were chosen in this work too only for strontium. The reagent Sr $(C_2H_3O_2)_2$ were used.

A culture of *Spirulina platensis* was irradiated at a dose of 150 kGy for 95 days. The radioisotope ^{137}Cs served as the gamma radiation source. The emitter power was 1.1 Gy/min. Irradiation was carried out at room temperature (25-20°C) in a day/night mode.

RESULTS AND DISCUSSIONS

Effect of strontium ions on the absorption spectra of control and irradiated and re-cultivated spirulina cells were studied. It turned out, that in the case of intact spirulina, the action of strontium ions causes a change in the absorption intensity of spirulina. However, this change occurs slowly and gradually. The presence of various metal-binding functional groups such as –CO, –OH, –COOH, and $–NH_2$ may contribute to its ability to form complexes with cationic metals and prevent their systemic absorption [3]. After irradiation with 150 kg, as shown in our article [11], the structure of spirulina is fully restored and Cs+ ions effect on control and irradiated cells does not difference. But in the case of strontium, this interaction with spirulina takes on a different character. In particular, the addition of strontium after gamma irradiation and re-cultivation of spirulina results in a very rapid change in absorption intensity compared to the control, while the subsequent effect of strontium is almost negligible. Therefore, it can be assumed that in the case of irradiated spirulina, the first added strontium induces change that limits the action of subsequent strontium.

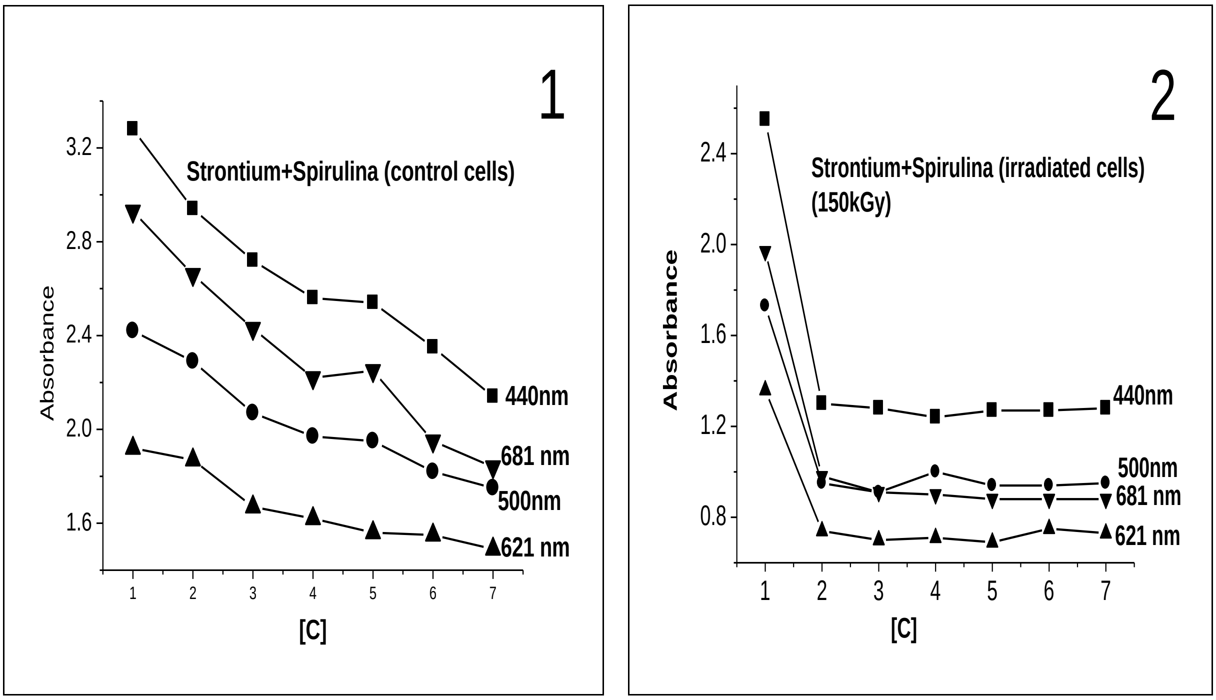

Figure 1. Effect of gamma radiation on changes in the spectral characteristics of spirulina components as control (1), as irradiated cells (2) after re-cultivation. (440 nm – Soret band of chlorophyll a.; 621 nm – Phycocyanin (basic protein); 681 nm – Chlorophyll a; 500 nm – Carotenoids).

Similar effects to those directly affecting spirulina will be observed for its components. In particular, strontium supplementation has a similar effect on chlorophyll a, carotenoids, and C-phycocyanin in intact spirulina. As can be seen from Figure 1, strontium causes a gradual decrease in absorption intensity for cases chlorophyll a, carotenoids, and C-phycocyanin in intact spirulina. Chlorophyll a is important for life on this planet because these energy-carriers cause the process of organic compound synthesis [12]. It is favorable for photosynthesis, supplying the ATP and NADPH necessary for the growth and survival of *Spirulina* sp. In addition, it has been suggested that chlorophyll *a*, detoxifies the body from lethal agents, and improves liver function in human/animal bodies [13]. Phycocyanin stands out as a characteristic pigment-protein complex that confer significant health benefits. Phycobiliproteins, located on the thylakoid surface are essential accessory pigments of cyanobacteria, capturing nearly 50% of absorbed light. *Spirulina* sp. is seen to encompass 14.18% of phycocyanin providing an array of protection preventing the development of inflammatory diseases, cancers, and atherogenic conditions, including chronic ailments and reducing cognitive impairment such as Alzheimer's Disease or Parkinson's Syndrome [14,15]. Spirulina (*Arthrospira platensis*) is a rich source of carotenoids, containing high levels of β-carotene. These lipid-soluble pigments serve as antioxidants and provitamin A sources. The carotenoid bioavailability from these microalgae has great potential as a source of provitamin A [16]. Its significant ability to interact with metal ions, serving as a biosorbent and providing protective effects against heavy metal toxicity. Carbohydrates and proteins, posed resistence to heavy metals toxicity suggesting their role in metal chelation. It is possible that irradiation caused Spirulina to become resistant to it, but the chelating effect of metals and radionuclides was altered. This can explain the effect of strontium on Spirulina components in Fig. 1, where for each Spirulina component (chlorophyll, carotenoid, ω-phycocyanin), the first addition of strontium causes a strong chelation effect, which is not observed with the addition of further concentrations. It is in good agreement with literature data [3,9], by which spirulina showed potential adsorption eciency and may be used as a cost-effective, ecient and non-toxic agent for removal of strontium from body.It should be noted, that in vivo removal efficacy of spirulina for strontium was assessed in Swiss albino mice[9]. The experiment was conducted with strontium (30 mg kg-1) to determine the in vivo removal efficacy of spirulina for these metal ions. In a preliminary study, was found that orally administered strontium dose less than 30 mg kg-1 were not detected in most of the soft tissues after 24 hours because most of the strontium was either excreted or accumulated in bone. An increase in the metal ion concentration showed a significant increase in the metal binding capacity of spirulina, but was found to be different in different physiological solutions [9].

CONCLUSIONS

Strontium is one of the most important radionuclides produced by nuclear fission. It enters the body through ingestion, inhalation, and skin and accumulates in tissues and organs. Therefore, it is of great importance to study the adsorption of radionuclides and heavy metals by Spirulina.

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