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Review Article

GREENING OF AMALNALA LAKE, GADCHANDUR, CHANDRAPUR DISTRICT (M. S.) - PROBABLE REASONS

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ABSTRACT

Amalnala dam is located at the foothills of Manikgarh hillock in Gadchandur town of Chandrapur district in Maharashtra state. The medium-scale irrigation dam is a main source of water for surrounding villages and local industries. It is also a well-known tourist spot. From last couple of years, water of the dam is turning dark green, especially, in the month of August resulting in the increased viscosity and stinking of water. This increased our curiosity to test the water sample for any biological origins. Preliminary microscopic examination showed the presence of *Microcystis*, a neurotoxic cyanobacteria which is green in colour and probably imparts green colour to water. The excessive growth of single cell cyanobacteria or the algal bloom can be due to rise in nitrates and phosphate levels in water. Thus, it becomes necessary to study the source of nitrates and phosphates and its possible bioremediation with the help of microbes and effect of neurotoxin produced by cyanobacteria on animal and human health. This review discusses various factors such as turbidity, light, temperature, pesticides, fertilizers etc. for the greening of the Amalnala dam.

Keywords: Amalnala; pesticides, turbidity, algal bloom, cyanobacteria.

1. INTRODUCTION

Global population is approaching 8 billion in 2021 and its impact on environment and ecology has been notable. Among them water pollution has been the greatest environmental issues owing to the higher demand of drinkable water. Water pollution is mainly caused by the eutrophication of water entities such as ponds, lakes and rivers [1, 2]. Eutrophication is the process of enrichment of water with excess nutrients, nitrogen and phosphorous which is responsible for the excess algal growth, periphyton or macrophytes. Continuous addition of organic matter to the water bodies also contributes in eutrophication. The causes of eutrophication are complex, as eutrophication involves various economic, social, ecological and numerous other factors [3]. The joint effect of natural and human activities mainly contributes in the eutrophication of water bodies which are also the root causes for the algal blooms and fish kills. Conversion of water bodies from oligotrophic to eutrophic is a natural process and takes years for achieving eutrophic level but the human intervention has accelerated this process. Therefore, it is important to monitor the water quality and identify the risk of eutrophication and adopt quick measures for its potential management [4]. Trophic status of lakes can be determined by the guidelines of Organization for Economic Cooperation and Development (OECD), indicates that the phosphorous levels greater than 35 µg l^{-1} signifies the eutrophic nature of lake. Amalnala dam is located at the foothills of Manikgarh hillock in Gadchandur town of Chandrapur district, Maharashtra state (19°41'17"N, 79°9'37"E). The medium-scale irrigation dam is a main source of water for surrounding villages and local industries. It is also a well-known tourist spot in Chandrapur district. Amalnala dam was constructed by Maharashtra government as a part of irrigation project in year 1985. Fishing activities are carried year-round in these waters. It is constructed on Amalnala River. Nearest city to dam is Gadchandur. The type of dam is Earth fill with diameter of 1607 m and height of 37.75 m. The dam has ungated spillway with catchment area of 8,417 hectors. Maximum storage capacity is 25.98 MCM. Live storage capacity is 24.48 MCM. Most of the water bodies like dams and ponds are famous as a picnic spots. Amalnala Lake is also one of the popular tourist attractions for its hilly terrain,

scenic beauty and lush green forest which again adds to the natural beauty. From last couple of years, water of the dam is turning dark green, especially, in the month of August resulting in the increased viscosity and stinking of water (Fig. 1).

Greening of water can be attributed to the change in the colour of water body to green which usually appears turbid or transparent year-round. The change in appearance of water body can be attributed to dissolved or suspended materials in the water. Organic matters such as leaves, roots, plant remains etc. contributed the addition of dissolved materials such as tannins. The slow degradation of plant materials results in the formation of dissolved organic matters which imparts colour to the water. Suspended material in water bodies may be a result of natural causes and/or human activity. Transparent water with a low concentration of dissolved materials appears blue. Dissolved organic matter, such as humus, peat or decaying matter, can impart a yellow or brown colour. Cyanobacteria, algae or dinoflagellates may impart red or yellowish colour to water bodies. Green colour may be imparted by the phytoplankton and green algae grown in the water as a result of eutrophication.

Eutrophication is characterized by the increase in phosphates, nitrates and sulphates in the lake. These high doses of nutrient usually contribute in the growth of cyanobacteria. Previous studies of eutrophic water bodies have showed the presence of neurotoxic cyanobacteria (*Microcystis*) which is green in color imparting green color to water [5]. The excessive growth of single cell cyanobacteria can be due to rise in nitrates and phosphate levels in water which in other words is known as eutrophication. Eutrophication of lakes has allowed the growth of various neurotoxic cyanobacteria such as Microcystis, Synechococcus, Trichodesmium, Snowella, Nostoc, Hapalosiphon [5] On the basis of the preliminary studies the hypothesis has been established as shown in Fig. 1.

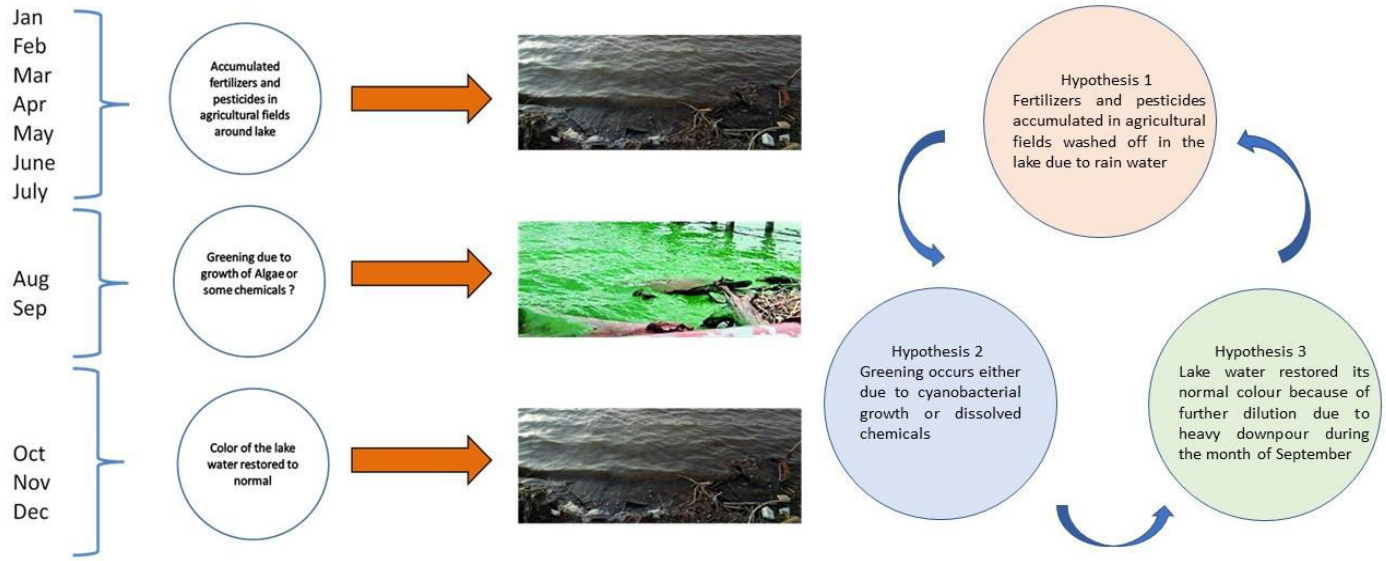

Fig. 1:Hypothesis for greening of Amalnala Lake, Gadchandur

2. PROBABLE REASONS OF GREENING OF AMALNALA LAKE

2.1. Excess nutrients and eutrophication of Amalnala Lake

One of the greatest water pollution challenges in the recent times is eutrophication caused due to the enrichment of water bodies by excess nutrients. Excessive phosphorus and nitrogenous compounds are the major sources of eutrophication [6-8]. Apart from that, acidification of freshwater lakes and streams [9], forest decline, climate change [10], disturbances to ecosystems and changing decomposition rates also contributes in eutrophication. Of all the environmental concerns related with excessive nutrients, eutrophication consistently ranks as the leading surface water quality impairment and is directly related to public health issues, economic impacts, ecological concerns and aesthetic impairments. In the world almost half of the impaired lake area and 60% of impaired river are due to eutrophication [11]. To overcome this problem,

an effective nutrient management strategy is essential to protect quality of surface water, aquatic ecosystems, public health and economic benefits. Variations in hydrologic behavior, geology dominated by limestone and both industrial and agricultural land use can dramatically influence nitrogen and phosphorus loads to receiving waters such as Amalnala dam.

Table 1:Sources of phosphate and nitrates inputs in lakes and rives

Sources of phosphates and nitrates
Water runoff from agricultural lands
Effluent runoff from the industries
Runoff from waste disposal site and animal feedlots
Runoff from storms and sanitary sewers
Runoff from construction sites
Leachate from abandoned mines

Furthermore, several complex mechanisms existing within a water body (e.g., phosphorous spiraling, hydraulic retention time, the phosphate buffer and light availability that affects the concentration and availability of nutrient concentrations leading to eutrophication. The relationship is established between increased growth yields and nutrient supply. It has been known and studied extensively since the work of the German agricultural chemist Justus von Liebig in the mid-1800s. By early 1900, there was evidence of a link between nutrients and aquatic productivity, or eutrophication [12]. Till date, the complexity and heterogeneity of watersheds has been the largest challenge in developing a well-defined numeric nutrient standard. Variations in hydrology, ecology, pesticides, sewage water management and ecological nutrient uptake all contribute to the eutrophication and the challenge of developing a management strategy that will protect the surface waters of our country.

Table 2:Effects of eutrophication on lake water properties

Effects of eutrophication
Increase in biomass and phytoplankton
Oxygen depletion
Increase in bloom forming species which can be toxic
A reduction in fish harvesting
Decrease in water transparency, foul odour and bad taste
Increased biomass of consumer species

Thus, it becomes necessary to study the source of nitrates and phosphates and possible bioremediation with different methods such as treatment of water by specialized filter or degradation of pesticides by microbes.

2.2. Optimum growth conditions for the growth of algal blooms

Algal blooms is the consequence of variety of factors ranging from human intervention to the environmental factors. The environmental factors contributing for the proliferation and growth of algal population includes the combination of physicochemical factors such as pH, carbon availability, salinity, conductivity, ecosystem disturbing factors such as stable or mixing of water and turbidity. Hydrological conditions influenced by river flow and water storage levels. Environmental factors such as sunlight, available nutrients and temperature of the water bodies. However, the exact combination of above factors that trigger and sustain an algal bloom is not well studied and it is impossible to correlate the algal blooms to any factor specifically. These conditions are further aggravated by the human interference with environment and cultural eutrophication. Increase in human global population have contributed in the increase of cultural eutrophication [13].

2.3. Effect of nutrients on growth of algae

Nitrogen, phosphorous, carbon etc. are the basic nutrients for the algal blooms. These nutrients available in optimum conditions, initiates, promotes and sustain the algal or cyanobacterial blooms. Enrichment of nutrients resulting in the formation of oligotrophic water bodies leads to the eutrophication. The eutrophication of waterways is considered as a major factor for the growth of algae. The main nutrients contributing to eutrophication are phosphorus and nitrogenous compounds. In the landscape, runoff and soil erosion from fertilized agricultural areas and lawns, river beds, river bank erosion, deforestation, and sewage effluent are the major sources of phosphorus and nitrogen entering water ways. All of these are considered as external sources. Sediments act as the internal origin contaminants. Phosphate attaches to sediments and when dissolved oxygen concentration is low in the water (anoxic), sediments release phosphate into the water column. This phenomenon enhances the phosphates and allows the growth of algae and results in the algal bloom [14]. There is the shift of growth in phytoplankton community to cyanobacterial growth

[14]. According to empirical calculation growth of cyanobacterial can initiated at the phosphorous concentrations between 100 μg l^{-1} to 1000 μg l^{-1} [15].

2.4. Temperature dependence of algal booms

Range of temperature has deep impact on the algal blooms. Algal blooms start towards the beginning of the spring where the intensity of the light is highest and the temperature also increase. Usually blue-green algal blooms develop during this season. Algal blooms are sustained during warmer days of the year. Water temperatures above 25°C supports the growth of cyanobacteria. At these temperatures, blue-green algae dominate over other types of algae whose optimal growing temperature is much lower usually between 12°C to 15°C. In temperate equatorial regions, lower temperature during winter months is not suitable for sustaining the growth of blue-green algal blooms. Higher water temperatures in tropical regions may cause blue-green algal blooms to persist throughout the year [16].

2.5. Light plays a major in growth of blue-green algae

Long duration of high light intensities is inhibitory for the growth of blue-green algae populations. This photo-inhibition checks the growth of algal blooms but the intermittently exposed high light intensities are favorable for their growth. These conditions are met under the water surface where light environment is fluctuating. In turbid conditions or in the conditions of low light the blue-green algae can also grow luxuriantly with higher growth rates than any other types of algae [16]. Thus, a critical competitive advantage of flexibility of growth in all types of light conditions gives the cyanobacteria evolutionary benefit to sustain their growth in variety of water bodies and lakes such as Amalnala.

2.6. Stable Conditions and its effects on algal blooms

Stable water conditions of low flow, low turbulence, light winds and long retention time with low tides and turbid environments are the most favorable conditions for the growth of blue-green algae. Other type of algae prefers mixing water conditions and turbulent environments. Since, Amalnala dam is built as a part of irrigation project on Amalnala river, it slowed the flow of river. Decrease in the water flow can also be brought by drought, water extraction for irrigation, human and stock consumption and the regulation of rivers by dams. In standstill water conditions water becomes ponded, which encourages the growth of algae. In water bodies, another consequence of stable conditions is thermal stratification. In thermal stratification the upper region of water column becomes warmer as compared to the lower and deeper water column. These temperature changes results in the stability of the water body and the mixing of water are also halted. This is when the upper warmer layer in summer months supports the growth of blue-green algae resulting in the buoyant algal blooms. When a water body is stratified, bottom waters often become depleted with oxygen. These anoxic conditions may lead to increased nutrient release from the sediments supporting the growth of cyanobacteria [17]. Source of nutrient from the colder bottom layer may fuel up the algal growth in the top layer.

2.7. Turbidity affects the algal growth

Reduction on the water appearance due to the presence of suspended particles and scattering of the light is turbidity. Turbidity is caused by the presence of suspended particles and organic matter (flocs) in the water column. Heavy downfall followed by heavy runoff of water and the acid rains are the main factors contributing the high turbidity of the water body. Less suspended particles in the water body causes less turbidity. Stable or slow-moving water allows the suspended particles to settle down resulting in the low turbidity. Low turbidity increases the availability of light to the lowest strata of the water column and benefits the growth of algae. This creates optimal conditions for algal growth. In return, growing algae create a turbid environment [18].

2.8. Mitigating of pesticide pollution by microorganisms

Both abiotic and biotic factors are responsible for the fate of the pesticides (Fig. 2). Degradation of pesticides by action of microorganisms is known as biodegradation [19]. Rate of degradation of pesticides is variable. Recalcitrant pesticides such as DDT (1, 1, 1-trichloro-2, 2-bis-(*p*-chlorophenyl) ethane) and dieldrin take longer time to get degraded and thus remain for the longer time in environment. These pesticides accumulate into the food chain [20].

Pesticides such as the organophosphates are now used preferably than more persistent chlorinated pesticides. Pesticides such as Atrazine and simazine have comparatively very slow rate of biodegradation. This

increases their chances of getting leached from soil to ground water, and contaminate drinking water sources [21]. Some pesticides are very fast degrading but low bioavailability decreases the rate of effectiveness of such pesticides. Examples of such pesticides are carbofuran and diazinon. They are broken down so rapidly under certain soil conditions that they may not allow effective pest control [22]. Thus, depending on the type of pesticides and their degradation rates, they should be chosen wisely and it is also import to study the fate of particular pesticide in environment and the factors that limit their activity *in situ*. The mechanism of degrade pesticides by microbes has been studied and reviewed in depth and extensively [23-25]. Thus, it is important to study the bacterial metabolism factors influencing the degradation of pesticide degradation, genes involved in the catabolic pathways of the degradation. All the factors will holistically contribute in the selection and application of pesticides so as to avoid ground water pollution and lake water pollution causing in greening of the lakes.

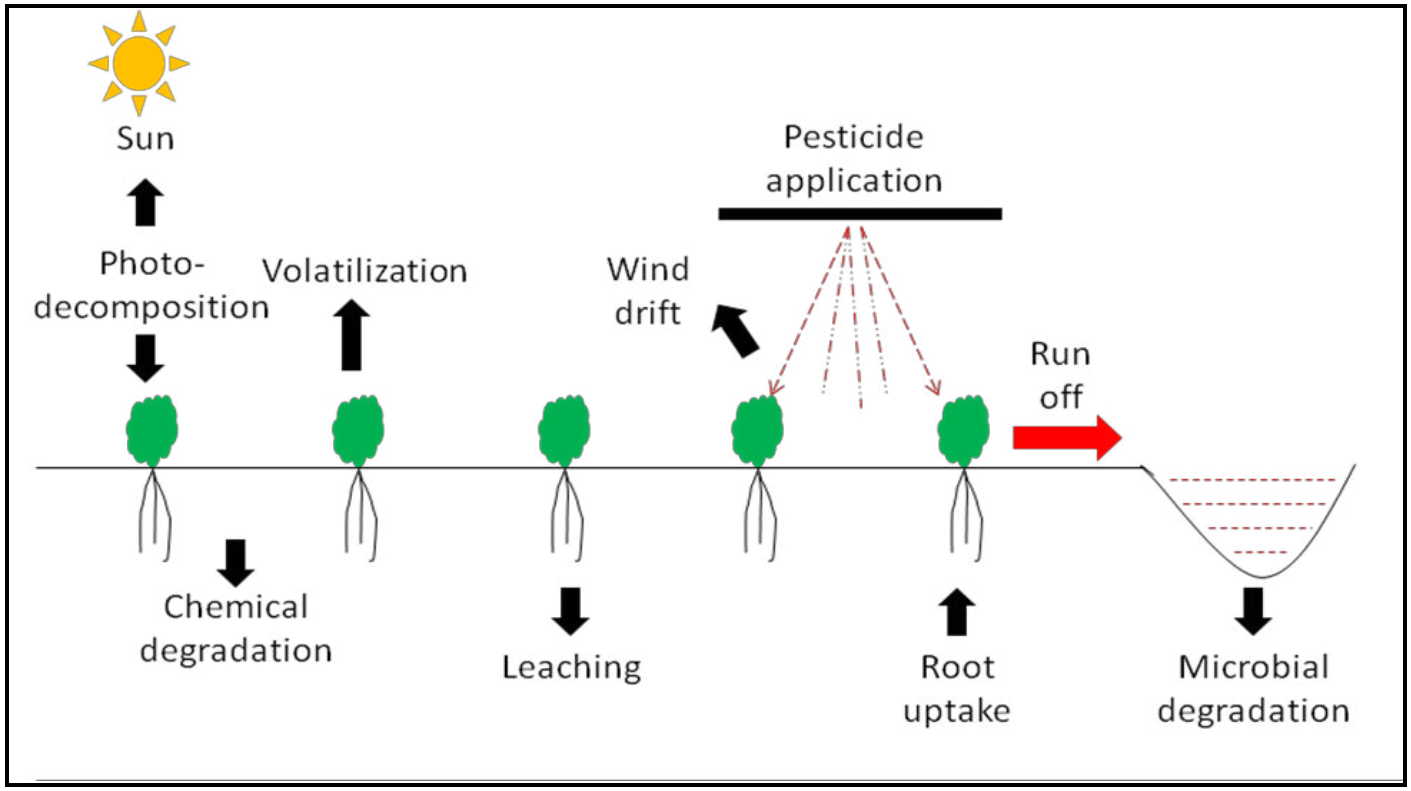

Fig. 2:Fate of pesticides in the environment

3. CONCLUSION

Effective management of the all the factors responsible of the growth of the cyanobacteria many avoid the greening of the Amalnala dam. In depth studies followed by the isolation and identification of the cyanobacteria followed by the physico-chemical studies of lake water, identification of the pesticides in the lake and mitigating the pesticide degradation by the microorganism will be the effective way to control eutrophication and algal blooms.

Conflict of interest

Authors declare that there is no conflict of interest.

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