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Original Research Article

AZOLLA BLOOM IN HANDIA AND JOGA- A COMBINED EFFECT OF UNUSUAL RAINFALL PATTERN IN WINTER SEASON AND EXCESS USE OF FERTILIZERS IN THE WHEAT FIELD.

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ABSTRACT

An abundance of phosphorus, due to eutrophication or chemical runoff, often leads to *Azolla* blooms. We explored the association of climatic conditions (i.e. annual rainfall and average minimum temperature during March and April) and water quality (phosphate and nitrate concentrations) with blooms of the invasive fern *Azolla* in the Narmada River flowing through Handia and Joga during March and April 2015. In the last decade there has been a considerable change in the climatic condition in India, winter season begins late and lasts till the end of March. Year 2015 has seen rainfall in January to April. The excessive use of phosphate fertilizers in the field is washed in to the water bodies by the runoff water. A positive co- relation observed between the growth of *Azolla* sp. *a*nd nutrient concentration in the river. The study shows that Handia and Joga is facing eutrophication and invasion by *Azolla* sp., most notably due to low temperature in March and frequent rainfalls in February to April.

INTRODUCTION

Eutrophication is a result of anthropogenic nutrient enrichment of water bodies (Howarth et al. 2011) consequently water bodies are displaced by the floating macrophytes, some of which may be invasive (Morris et al. 2003; Meerhoff et al. 2007; Szabo et al. 2010). Studies suggested that nutrients alone do not promote such changes and other environmental factors drive these

transitions (Feuchtmayr et al. 2009; Moran et al. 2010). Global Warming might have a synergistic effect promoting the invasion of free floating species (Netten et al. 2010).

Azolla is a serious weed in many parts of the world, entirely covering water bodies. It is a highly productive plant. *Azolla* spp. consists of a main stem growing at the surface of the water, with alternate leaves and adventitious roots at regular intervals along the stem. Secondary stems develop at the axil of certain leaves. *Azolla* fronds are triangular or polygonal and float on the water surface individually or in mats It doubles its biomass in 3–10 days, depending on conditions, and yield can reach 8-10 tones fresh matter/ha in Asian rice fields. 37.8 t fresh weight/ha (2.78 t DM/ha dry weight) has been reported for *Azolla pinnata* in India (Hasan et al., 2009). Azolla has been used, for at least one thousand years in rice paddies as a companion plant, because of the presence of nitrogen-fixing cyanobacteria in mutual symbiosis with it and its tendency to block out light to prevent any competition from other plants, aside from the rice, which is planted when tall enough to poke out of the water through the *Azolla* layer. Mats of mature *Azolla* can also be used as weed-suppressing mulch.

Although *Azolla* can grow on wet mud surfaces or wet pit litters, it prefers growing in a free-floating state. A strip of water not more than a few centimetres deep favors growth because it provides good mineral nutrition, with the roots not too far from the soil, and also because it reduces wind effects (Van Hove, 1989). *Azolla* sp. is unique among floating macrophytes, because it can grow in waters devoid of combined nitrogen, due to the symbiosis with a N_2 fixing cyanobacterium, *Anabaena azollae* that lives in the dorsal lobe cavity of its leaf. So, this plant can grow even after the exhaustion of combined nitrogen in secondary effluents, improving an adequate phosphorus removal (Kitoh et al., 1993) Infact, phosphorus is for *Azolla*, as for many other photoautrotrophic aquatic organisms, the limiting nutrient for growth. (Chakrabortty and Kushari 1986).

MATERIAL AND METHODS

The study was conducted in the Central part of Madhya Pradesh at Harda district at 22°14'N to 22°24'N latitude and 77°13'E to 77°23'E longitude. Handia and Joga, are the places of historical importance in Harda. The river Narmada flows through these two places. Handia is 21 Km north from Harda situated on the bank of river Narmada. It is Hindu, Muslim and Jain pilgrimage. Handia has a number of Hindu temples of Ramayana and Mahabharata periods, many tombs and forts constructed in Mughal period and an ancient and a new Jain temple. Conservation and

beautification of this place is done by the archeological survey of India. The naval point of the River Narmada is also at Handia. Joga is 40 Km from Harda. The fort in the middle of river Narmada is of great tourist interest. Both the places are famous for boat race.

The survey was carried out in February to April 2015. Due to western disturbance there was frequent storm, heavy rainfall and frost in February, March and April which has broken the record of 100 years. March and April in Harda are quite dry and hot months of the year. The actual terrific face of climate change and global warming was seen in the year 2015. The temperature was comparatively low in March and first half of April, but a slight rise in temperature observed by the end of April resulting into a prolonged winter season in 2015.

The growth rate and productivity of *Azolla* grown in the Narmada River flowing along Handia and Joga had been evaluated under confined conditions with 0.16 m2 circular floating PVC net frames, during seven weeks, from February to April, under the climatic conditions prevailing in the rural area. The natural photoperiod during this period averaged 11 h d^{-1}, with light intensities from less than 25 Wm^{-2} to about 51 Wm^{-2}. The air temperature ranged from 11.5 ^{0}C to 20^{0}C, the corresponding water temperature ranged from 10.5^{0}C to 15^{0}C, and the mean relative humidity was about 85%.

RESULTS AND DISCUSSIONS

Climatic conditions and eutrophication aided the development of Azolla in the Narmada River flowing through Harda. Throughout the paper, February to March is assigned as the hydrological months and not an ordinary month. In general, *Azolla* cannot survive winters with prolonged freezing and also has low tolerance to high temperature. The warm months of March and April was comparatively cold favored the growth of *Azolla.* The early expansion of *Azolla* mats during late winter and early spring might enhance its own growth by warming up the top layer of water through the absorption of irradiance, and reducing water mixing through a reduction in wind action (Room and Kerr 1983). This process might be important in wind protected areas or in open waters where *Azolla* mats can be significantly large. Our results are consistent with the hypothesis that temperature might be an important factor determining the fitness of floating macrophytes (Janes 1998; Van der Heide et al. 2006; Peeters et al. 2013).The untimely rain in Harda in 2015 caused runoff of excess fertilizers accumulated in the field into the river especially during the period when the flow of river was reduced. Consequently average orthophosphate concentration in the Narmada River could have increased significantly. Although

several experimental studies conducted under controlled conditions have found that Phosphorus addition and high temperatures increase *Azolla* biomass (Cheng et al. 2010). There is a strong positive correlation between orthophosphate and nitrate concentrations in the marshland an tributary streams indicating that eutrophication most likely occurs via external inputs, particularly in rainy years (Jose et al. 2015). Some of these streams receive run-off water from agricultural areas irrigated by groundwater wells or small dams, waste-water effluent from urban areas, and sewage effluents from wastewater stations (Serrano et al. 2006). The shift from floating to submerged macrophytes has been proposed as alternative stable states defined as the result of asymmetric competition mediated by nutrient and light availability (Scheffer et al. 2003).

Azolla covered the Narmada River in both the sites in March and April made navigation very difficult. Every Amavasya thousands of people collect on bank of Narmada River in Handia for holy bath. In March 2015 the pilligrims could not take holy bath because of overcrowding of *Azolla* on the bank of the river. Similarly tourist in the Joga could not reach to the historical fort standing in the middle of river Narmada. *Azolla* which was spread out during early spring when the study site was flooded, completely dried by the last week of April. Strong winds accumulated *Azolla* to one side of the stretch of water, creating an overcrowded condition and slowed the growth. Previous of drying *Azolla* acquired slightly reddish color, sting badly, rottened and finally died. Most of the species can produce large amounts of deoxyanthocyanins in response to various stresses (Wagner 1997) including bright sunlight and extremes of temperature,(Moore 1969, Zimmerman 1985) causing the water surface to appear to be covered with an intensely red carpet.

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