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Effect of water pollution on *Pistia stratiotes* in river Suheli of Dudhwa National Park and river Gomti of Lucknow city

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Abstract: Aquatic vascular plants play an important role in the uptake, storage, and recycling of metals. The uptake of metals depends on redox potential, chemical form of element and on the life form of the macrophytes. *Pistia stratiotes* a free-floating aquatic macrophyte absorb elements mainly through the roots. Effect of polluted water form the different experimental sites of Suheli and Gomti river were studied in plant *Pistia stratiotes*. Remarkable changes were observed in plant growth in water streames. The plants showed brown coloration signifying the damage of total chlorophyll content attibutable to the deficiency of nutrient ions, which are essential for photosynthesis.

Key words: *Pistia stratiotes*, Metals, Pigments, Catalase, Peroxidase, Sugar

Introduction

In recent years, because of continuous growth in population, rapid industrialization and accompanying technologies involving waste disposals, the rate of discharge of the pollutants into the environment is far higher than the rates of their purification. According to a WHO estimate (Bhuvaneswaran *et al*., 1999) about 80% water pollution in developing countries like India is caused by domestic wastes. Most of the rivers are deteriorating gradually and the maintenance of the quality of river water will be a severe problem in the years to come. According to surveys carried out by several researchers on some of the important rivers, it has been observed that in recent years, the water of most of these rivers is polluted. Works of Patel and Patel (1993) on Ganga; Praveen *et al*. (2003) also on Ganga; Patel and Patel (1993) on Yamuna river, Patel, and Patel (1993) on Mahanadi, Trivedi (2000) on Gomti *etc* indicate that most of the important and major rivers in most parts of the world are polluted by human activities.

Agrawala and Sharma (1982) reported that about seventy percent of the available water in India is polluted. Not only the surface water but ground water is also getting polluted due to leaching of the various type of toxic pollutants (Reddy *et al.*, 2001; Murali and Satyanarayana, 2001; Ubala *et al.*, 2001; Sharma *et al*., 2002). Reddy *et al*. (2001) reported the effect of the industrial effluents on the ground water pollution. Due to urbanization, civilization, population pressure and other developmental activities in the catchment area (Trivedi *et al*., 1990) majority of rivers in India are polluted. River provides water for different purposes to human beings, but same river are being polluted by indiscriminate disposal of sewage and industrial wastes. Several industries release toxic chemicals and heavy metals which are being dumped into rivers and change their physico-chemical properties. In India river water pollution has been reported to be indiscriminate disposal of industrial effluents (Trivedi *et al*., 1990; Mishra *et al*., 2002).

Materials and Methods

Dudhwa, now a single National Park situated in the Tarai area of state, Uttar Pradesh is and about 210 km away from the Lucknow; covering an area of 500 sq km along the Indo- Nepal border in Kheri district. This area was notified as wildlife sanctuary in 1965 and later as national park in 1977. The tarai ecosystem is one of the most threatened ecosystems of India. The region is vast flat alluvial plain lying between the Himalayan foothills and the gangetic plains it extends through Uttarakhand, northern Uttar Pradesh and Bihar, northwestern Bengal, Assam, and southern Nepal. It forms an integral part of the tarai- Bhabhar bio-geographic sub-division of the upper gangetic biotic province and gangetic plains bio-geographic zone (De *et al*., 2001-2009). Suheli river is called as life line of Dudhwa National Park. Suheli river after entering India from Nepal demarked the south boundary of Dudhwa National Park. In Nepal this river is called as Donda, which after flowing on the sleeping slopes of Churia hills, into Indian forest at kaima region of sathiyana range.

Gomti river has an effective catchment area of about 28500 sq kms (about 8.7% of U.P. State), and is inhabited by 15 million people. In the initial reaches, Gomti river remains more or less like a stream till it reaches Mohamdi about 100 kms from the origin and it is at this stage that it starts to take the shape of well defined river. After further traversing a stretch of about 100 kms from the origin it is joined by prominent tributary called Saryan which during dry season basically carries spent water and sullage from inhabitation in district Sitapur. It has also been found to carry contaminated effluents from the sugar factories and distilleries in the area. After traversing about 40 kms more towards south, the river enters Lucknow, having a population of Lucknow is about 25 lakhs. At the entrance of the town about 280 million litters per day water is lifted from Gomti river for water supply of Lucknow city.

For the qualitative assessment of Suheli river (Dudhwa National Park) five sampling points were selected between Kaima

Chaowki upstreams about 48 km stretch of Suheli river and Suheli barrage (Fig. 1) and Gomti river water, a 15 kms stretch was selected between Gaughat upstream and Pipra ghat in Lucknow (Fig. 2). The experiment was performed in triplicates. Each pot was filled with polluted water collected from different points. A control level was also maintained. The ground water was treated as control. Every pot contained two plants

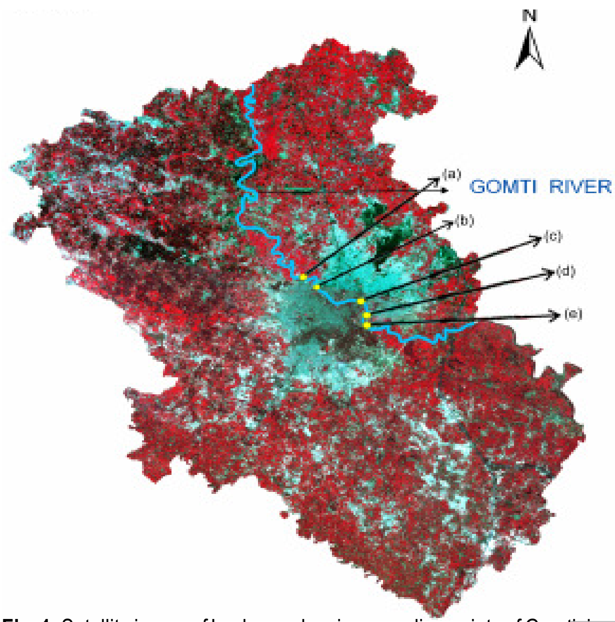

Fig. 1: Satellite image of Lucknow showing sampling points of Gomti river *i.e.* (a) Up stream Gaughat (b) Down stream of Mohan Meken (c) Down stream of Nishatganj (d) Down stream of Gomti barrage and (e) Pipraghat

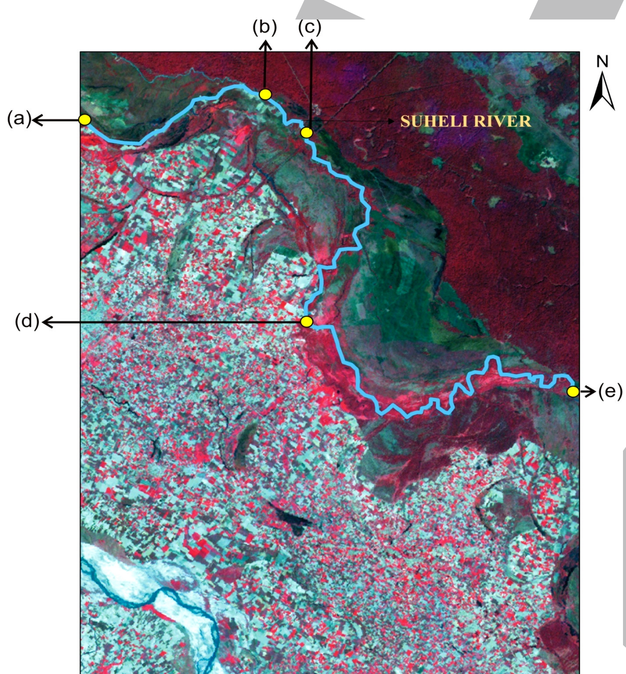

Fig. 2: Satellite image of Dudhwa National Park showing sampling points of Suheli river *i.e* (a) Kaima region (b) Tiger haven (c) Road bridge (d) Basantpur village and (e) Suheli barrage

and the experiment was set under the natural conditions. The water was changed at regular intervals. The levels maintained were control level, Suheli Kaima Chowki upstream, PWD bridge upstream, Suheli upstream barrage, Upstream Gaughat water intake Gomti river, University bridge upstream and Gomti bridge upstream. Chlorophyll, protein and total sugar were measured by the method of Petering *et al*. (1940), Lowry *et al*. (1951) and Dubais *et al*. (1953) respectively. Activity of enzyme catalase and peroxidase was measured by the method of Bisht (1972) and Luck (1963) respectively. All the measurements were made in triplicate and the data presented are the mean of three replicates.

Results

Efficacy of polluted water from the different experimental sites of Suheli (relatively cleaned area) and Gomti river (polluted

Fig. 3: Variations in *Pistia stratiotes* plants growing at different experimental sites of Suheli rivers

Fig. 4: Variations in *Pistia stratiotes* plants growing at different experimental sites of Gomti river

Table-1a: Effect of water pollution on morphological parameters of *Pistia stratiotes* in river Suheli

Experimental sites	Plant height (cm)	Number of leaf	Root length (cm)	Plant fresh wt (g)	Plant dry wt (g)
Control	9.0 ±0.3	33 ±1	6.5 ±0.1	8.84 ±1.00	0.80 ±0.01
Kaima chauki	9.5 ±0.2	37 ±2	6.0 ±0.3	9.18 ±0.88	0.96 ±0.02
PWD bridge DNP	11.0 ±0.8	40 ±3	8.6 ±0.2	9.74 ±0.90	1.02 ±0.30
Suheli barrage	8.5 ±0.6	30 ±2	5.8 ±0.1	6.16 ±0.50	0.54 ±0.05
CD at 5%	0.51	0.44	0.29	0.51	0.11

Table-1b: Effect of water pollution on morphological parameters of *Pistia stratiotes* in river Gomti

Experimental sites	Plant height (cm)	Number of leaf	Root length (cm)	Plant fresh wt (g)	Plant dry wt (g)
Control	12.5 ±1.1	51 ±4	9.0 ±0.5	14.68 ±1.02	2.25 ±0.10
Gaughat up-stream	12.0 ±1.3	43 ±3	8.0 ±0.3	13.92 ±0.95	2.02 ±0.98
University bridge	11.0 ±0.6	34 ±1	7.5 ±0.2	12.86 ±1.03	1.80 ±0.20
Gomti barrage	9.0 ±0.8	29 ±2	7.0 ±0.3	10.25 ±0.50	1.30 ±0.10
CD at 5%	0.41	0.32	0.23	0.58	0.08

area) were studied in plant *Pistia stratiotes*. The plant height, leaf number and root length of pistia plants grown in the water of PWD bridge Dudwa National Park- the site of the Suheli river were found to be maximum while the plants grown in water of Suheli barrage showed the minimum values as compared to their control (Table 1a). However, the plants grown in the water of Gaughat upstream- the site of Gomti river were found to be healthy but the control plants showed the best result in terms of plant growth, root length and the number of leaves while the reduction in growth was observed in case of Gomti barrage as compared to its control. The fresh weight and dry weight of the plants grown in water of PWD bridge Dudwa National Park were found to be maximum as compared to the control plants whereas, the values of fresh weight and dry weight were found to be significantly decreased from Gaughat upstream to Gomti barrage as compared to the control plants of which the fresh weight and dry weights were found to be the highest (Table 1b).

The chlorophyll-a, chlorophyll-b and total chlorophyll were found to be maximum in the plants grown in water of PWD bridge Dudwa National Park and minimum in Kaima chauki- the site of Suheli river as compared to the control plants whereas the sites of Gomti river from Gaughat upstream to Gomti barrage showed the decreasing trend in the values as compared to their control where the Chl. a, b and Chl. a + b showed the highest values (Table 2a). The plants grown in the water of PWD bridge Dudwa National Park showed the highest values for carotenoids and lowest values for Chl. a:b ratio as compared to their control plants while chlorophyll: carotenoids ratio was found to be the maximum for the Suheli barrage and minimum for the Kaima chauki as compared to the control However, the sites from Gaughat to Gomti barrage showed the increasing trend in the values of carotenoids, and Chl, a:b ratio was found to be significantly increased for Gaughat and significantly decreased value for university bridge sites, the chlorophyll and carotenoid were found to be significantly decreased for Gomti barrage as compared to the control where the value was maximum for Chl: carotenoids ratio (Table 2b).

The protein and sugar concentration were found to be significantly increased in the plants growing in PWD bridge Dudwa National Park and the significantly decreased in the plants growing in Kaima chauki sites of Suheli river. However the sites of Gomti river from Gaughat to Gomti barrage showed the decreasing trend in values of protein and sugar as compared to their control plants (Table 3a). The activities of enzymes catalase and peroxidase were found to be significantly increased in plants growing at PWD bridge Dudwa National Park. While their activities were significantly decreased values for Kaima chauki sites of Suheli river. The sites of Gomti river from Gaughat to Gomti barrage showed the decreasing trend in values of the enzyme activities as compared to their control plants (Table 3b).

Discussion

According to Agrawala *et al.* (1977) the metals in waste water may cause the deficiency of iron and produce toxicity and symptoms resembling the iron deficiency. The plants showed the best result in terms of plant growth, root length, number of leaves, fresh weight and dry weight in the case of PWD bridge (Dudhwa National Park) site of Suheli river, the cause might be because of the availability of nutrients in this area due to the presence of agricultural land nearby this site. The values were found to be decreased from Gaughat to Gomti barrage sites of Gomti river because of the increased pollution levels. The toxic effluents containing heavy metals, wastes and other pollutants adversely affect the plant growth. Stunted growth, decreased length of roots and shoots as well as their fresh weight and dry weight were some of the adverse effects on the plant by these toxic metals which pollute water, they also cause reduction in biomass. The studies by Kich and Braoun (1978), Wickliff *et al*. (1980), Rao and Nandkumar (1983), Renjni and Janardhanan (1989), Yadav and Srivastava (1997) showed the reduction in biomass due to heavy metals present in the

Table-2a: Effect of water pollution on pigments (mg g^{-1} F.W.) of *Pistia stratiotes* in river Suheli

Experimental sites	Chl. a	Chl. b	Chl. (a+b)	Carotenoid	Chl. a/b ratio	Chl./Car. ratio
Control	0.700 ±0.06	0.171 ±0.02	0.871 ±0.03	0.15 ±0.01	4.09 ±0.06	5.80 ±0.06
Kaima chauki	0.687 ±0.03	0.170 ±0.01	0.857 ±0.01	0.16 ±0.02	4.04 ±0.03	5.35 ±0.05
PWD bridge DNP	0.742 ±0.02	0.200 ±0.02	0.942 ±0.03	0.17 ±0.02	3.71 ±0.05	5.54 ±0.04
Suheli barrage	0.706 ±0.01	0.176 ±0.01	0.882 ±0.02	0.15 ±0.01	4.01 ±0.06	5.88 ±0.03
CD at 5%	0.020	0.015	0.020	0.009	0.11	0.41

Table-2b: Effect of water pollution on pigments (mg g^{-1} F.W.) of *Pistia stratiotes* in river Gomti

Experimental sites	Chl. a	Chl. b	Chl. (a+b)	Carotenoid	Chl. a/b ratio	Chl./Car. ratio
Control	0.663 ±0.02	0.183 ±0.01	0.846 ±0.02	0.14 ±0.01	3.62 ±0.05	6.04 ±0.09
Gaughat up-stream	0.639 ±0.06	0.170 ±0.02	0.809 ±0.02	0.15 ±0.02	3.75 ±0.03	5.39 ±0.08
University bridge	0.597 ±0.03	0.169 ±0.01	0.799 ±0.01	0.16 ±0.02	3.53 ±0.08	4.78 ±0.09
Gomti barrage	0.558 ±0.04	0.156 ±0.01	0.714 ±0.02	0.18 ±0.01	3.57 ±0.04	3.96 ±0.07
CD at 5%	0.012	0.017	0.022	0.007	0.13	0.21

effluents. Fleming (1965) reported that increase of metal content in plants also depends upon the plant maturity and seasonal influences. The sodium ions and chloride ions in water were also known to cause the adverse effects on the growth of plant. Kacabova and Natr (1986) found decreased fresh and dry weight of whole plant, and root dry matter was reduced to a larger extent than shoot dry matter of the plants. Choudhury and Ain (2003) has observed inhibition in growth parameters and effect of pollutants concentration on growth of the plants (Boura *et al*., 1986; Prasad and Prasad, 1987). Sresty and Rao (1999) found growth reduction of plants under different pollutant concentration.

The metals in waste water may cause the deficiency of iron. Khan and Khan (1983) reported the importance of iron in photosynthesis of the plant. Fodor (2002) reported that the toxic metal disturbs the plant metabolism including photosynthesis. The photosynthetic pigments were found to be maximum in the plants grown at PWD bridge site of the river Suheli which might be due to availability of nutrients and iron from nearby agricultural areas through the runoffs whereas the chlorophyll content was found to be decreased and increased carotenoids in plants grown in water of Gaughat to Gomti barrage sites of Gomti river, this might due to the increased pollution and decrease in photosynthesis, the deficiency of iron might be the probable reason for the decreased chlorophyll content. The reports by Agrawala and Kumar (1962), Bisht (1972) indicate iron chlorosis at excess concentration of heavy metals. Induction of chlorosis or decrease in chlorophyll content of plant subjective to heavy metal toxicity is often associated with impairment of iron utilization in plants. Malhotra (1976) reported change in the structure of chloroplast under the effect of pollution and other toxic substances resulting in to swelling of thylakoids accompanied by an increase of volume of thylakoid loculi.

Common symptoms of pollutants toxicity are chlorosis and inhibition in the photosynthesis and respiration of plant system (Bazzaz *et al.*, 1974). Chlorophyll synthesizing system and chlorophyllase activity were affected by pollutants was reported by Sasadhar (1987). Pollutants induced reduction in both chlorophyll a, b and consequently the total chlorophyll content also. The reduction may be due to sensitivity of enzymes involved in chlorophyll biosynthesis and degradation towards pollutants (Drazkiewiez and Krupa, 1991). The carotenoids serve as an accessory pigment for photosynthesis, carotenoid is a part of photosynthetic pigment, playing an important role in protection of chlorophyll pigment under stress conditions. Carotenoids were known to quench the photodynamic reactions leading to loss of chlorophylls, replace peroxidation and collapse of membrane in chloroplasts (Knox and Dodge, 1985). An increase in the amount of carotenoids was found in the present study, which is in agreement to previous studies of *Pistia stratiotes* and *Vallisneria spiralis* as reported by Sinha *et al*. (2005), Vajpayee *et al*. (2001). The increase in the carotenoid level might be due to the ability of the plants to counteract the toxic effect of free radicals generated under stress.

The present study revealed the decrease in protein concentration with the increase in pollution levels. The PWD bridge site of Suheli river showed the highest value for protein due to availability of nutrients and runoffs from the nearby agricultural fields that might have affected the nitrogen metabolism of the plants. The decreasing trend in proteins was observed from Gaughat to Pipraghat sites of Gomti river due to increased pollution and increased toxic metals. Possibly the decreased amount of total protein have resulted from toxic effects of the metals in the water on the nitrogen metabolism of the plant. Another reason might be due to the effects of reactive oxygen species. The decrease in protein content was probably due to the adverse effects of reactive oxygen species, which may be due to degradation in proteins. Rai (1995) has earlier reported the altered protein profiles at heavy metal stress condition.

The sugar is an important constituent manufactured during photosynthesis and breakdown during respiration by plants. The lower sugar level may be due to lowered synthesis or diversion of the metabolites to other synthesis processes (Tripathi and Tripathi,

Table-3a: Effect of water pollution on biochemical parameters of *Pistia stratiotes* in river Suheli

Experimental sites	Protein (mg g^{-1} F.W.)	Sugar (mg g^{-1} F.W.)	Catalase (units mg $protein^{-1}$)	Peroxidase (units mg $protein^{-1}$)
Control	57.99 ±0.98	0.42 ±0.01	2.5 ±0.02	0.18 ±0.03
Kaima chauki	53.71 ±0.96	0.41 ±0.03	2.3 ±0.01	0.17 ±0.02
PWD bridge DNP	60.11 ±0.75	0.59 ±0.02	2.7 ±0.03	0.24 ±0.03
Suheli barrage	56.43 ±0.36	0.44 ±0.01	2.4 ±0.02	0.19 ±0.01
CD at 5%	2.01	0.11	0.11	0.10

Table-3b: Effect of water pollution on morphological parameters of *Pistia stratiotes* in river Gomti

Experimental sites	Protein (mg g^{-1} F.W.)	Sugar (mg g^{-1} F.W.)	Catalase (units mg $protein^{-1}$)	Peroxidase (units mg $protein^{-1}$)
Control	64.25 ±1.02	0.56 ±0.03	2.8 ±0.06	0.22 ±0.03
Gaughat up-stream	61.33 ±1.03	0.39 ±0.01	2.5 ±0.02	0.17 ±0.01
University bridge	58.01 ±1.05	0.31 ±0.01	2.2 ±0.06	0.16 ±0.01
Gomti barrage	56.61 ±1.11	0.28 ±0.02	1.9 ±0.05	0.12 ±0.01
CD at 5%	1.95	0.09	0.15	0.08

1999). Thus reduced sugar content in polluted plants might have resulted due to the adverse effect of toxicity on the process of photosynthesis. Excess concentration of pollution caused reduction in total sugar content in *Pistia stratiotes* plants. Agrawala *et al*. (1977) have reported increase in pollution concentration of reducing sugar at excess supply of heavy metals. The PWD bridge site of Suheli river showed the highest value for sugars due to availability of nutrients and iron through the runoffs from the nearby agricultural fields that might have positive effect on the photosynthesis of the plants that in turn affected the sugar content. Another reason might be because of the presence of some metals at this site that are responsible for the improper translocation of sugars from leaf to other parts of the plants and some metals also results in a significant accumulation of non reducing sugars. The decreasing trend in sugar was observed from Gaughat to Pipraghat sites of Gomti river due to increased pollution and increased toxic metals. This might have resulted due to adverse effect of toxic doses of some heavy metals in water on the process of photosynthesis.

Activity of both iron enzymes *viz*., catalase and peroxidase was found to be decreased in the leaves of plants of *Pistia stratiotes*. The PWD bridge site of Suheli river showed the highest value for catalase and peroxidase, the reason might be the sufficient supply of iron for the synthesis of catalase. Catalase changes its activity depending upon the plant species and heavy metal type. The stimulation in the activity of peroxidase enzyme was found to be correlated with metal ion concentration. Some metals were also responsible for the increased activity of these enzymes. The decreasing trend in catalase and peroxidase was observed from Gaughat to Pipraghat sites of Gomti river due to increased pollution and increased toxic metals. Panda and Patra (1997) reported oxidative damage and biochemical lesions in plant cells due to pollution. Pollutants toxicity results in proline accumulation and alteration of various enzyme activity (Panda *et al*., 2003), changes in growth and metabolism of plants by *in- vitro* uptake of pollution resulted secondary responses such as oxidation damage by producing highly reactive oxygen species (ROS). Activity of antioxidative enzyme directly resulted with the steady state level of ROS in the cell and augmentation of the antioxidative defense plays a vital role in regulating oxidation stress (Hegedus *et al*., 2001). Decrease in catalase activity due to pollutants toxicity in plants could result from the attack caused by pollution induced ROS, which might be causing elevated lipid peroxidation indirectly resulting in free radical production. A greater activity of the enzymatic compounds of the antioxidative system indicates the high pollution stress condition in plant and changes in the activity of enzymes depend on plant species and pollution type. However, the activity of catalase was found to be decreased possibly due to more generation of ROS and H_2O_2 against this enzyme. Catalase might have unable to cope with ROS generation. Reduced catalase might also be due to insufficient supply of iron for synthesis of catalase.

Peroxidase, which are known for their vital role in biological system by way of catalytically oxidizing a wide variety of electron donor substrate species bearing phenolic amine or acid function aided by H_2O_2 or organic peroxides. Peroxidases are known to play significant role in oxidative stress conditions. Bisht *et al*. (1976), further reported unfavourable change by ROS which can be prevented by the defence mechanism of plants *i.e.*, the antioxidative system, which includes enzymatic compounds such as catalase and peroxidase.

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