Environment and Ecology 38 (4) : 827—834, October—December 2020
ISSN 0970-0420

Limnological Studies of River Yamuna at Kalpi Stretch, U.P. India

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Received 5 October 2020, Accepted 4 November 2020, Published on 2 December 2020

ABSTRACT

Limnological studies of an aquatic ecosystem reveals the pollution status of studied water body because there is strong relationship between aquatic organisms and fresh water environment. Evaluation of water quality of any water bodiesrequiredlimnological studies. These studies includesthorougly investigation of physico-chemical and biological parameters of a water body. Limnological studies of the Yamuna river at Kalpistretch was carried out for a period of one year.Purpose of studies was to evaluation of the river water quality from various angles of physico-chemical and biological parameters.Four sampling sites were selected for sampling purpose. Collected samples were evaluated forfourteenphysico-chemical parameters such as W.T., pH, Conductivity, Turbidity, T.D.S., T.H., T.A., Cl, SO_4, PO_4, NO_3, D.O., B.O.D. and C.O.D. and fourbiological parameters such as phytoplankton, aquatic macrophytes, zooplankton and fishes. Present limnological study reveals that water quality of the Yamuna river was not fit for drinking purpose but it was satisfactory for fish culture and irrigation purpose. Presence of both pollution tolerant and pollution intolerant species of biological parameters shows that this water was moderately polluted.

Keywords: Biological parameters, Kalpi, Limnological studies, Physico-chemical parameters, Yamuna river.

INTRODUCTION

Limnological study includes the study of relationship between organisms and the fresh water environment. Fresh water is the basic need of life supporting activities. Although water covers 71% of the total surface of the earth but hardly 1% is available as fresh water of which some part is found in the rivers.Rivers like Ganga, Yamuna, Gomti, Ghaghra, Ken, Betwa and Paisuani are the important source of water in Uttar Pradesh. The Yamuna river is largest tributary of the Ganga river, originates from Yamunotri glacier near BanderPunchh peaks of the lower Himalayas in Uttarkashi district of Uttarakhand and confluences with Ganga river atPrayagraj by covering a distance of 1376 km. Total catchments area of the Yamuna river is 3,66,223 km^2, which includes 3,46,848 km2 area in different states and 20,375 km^2 the Yamuna river area (CPCB 2006). The Yamuna river is also

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influenced by pollution problems as like other rivers of the world. Various urban centers are located on the bank of river Yamuna, Kalpi is one of them. In the Kalpi sources of pollution in the Yamuna rivercovers domestic sewage,dumping of garbage, industrial effluent, agriculture run off, immersion of idols, dead bodies and cremation of dead human bodies on river bank. Considering the importance of rivers as fresh water resources, several studies have been conducted (Sharma et al. 2008,CSE 2009, Mishra et al. 2009,Chopra et al. 2012,Chandra et al. 2014, Khare and Kumar 2014, Kumar et al. 2014, Kumar and Khare 2015, Kumar et al. 2015, Kumar et al.2016, Kumar 2017, Kumar 2018).Evaluation of water quality of any water bodies required limnological studies which includes evaluation of various angles of physico-chemical and biological parameters.In the present limnological studies of river Yamuna fourteen physico-chemical parameters and four biological parameters have been selected for evaluation of water quality. This study was necessary because a big population of Kalpi city is depend on Yamuna river for drinking water and no scientific data about the water quality at Kalpi stretch of the Yamuna was exists before this study.

Aim and objectives

Objectives of the study was to analysis ofselected physico-chemical parameters such as Water Temperature (W.T.), Hydrogen Ion Concentration (pH), Conductivity, Turbidity, Total amu Dissolved Solids (T.D.S.), Total Hardness (T.H.), Total Alkalinity (T.A.), Chloride (Cl), Sulfate (SO_4), Phosphate (PO_4), Nitrate (NO_3), Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) and Chemical Oxygen Demand (C.O.D.) and compare with maximum permissible limit for drinking water as recommended by W.H.O. and to analysis of biological parameters such as phytoplankton, macrophytes, zooplankton and fishes of the Yamuna river at Kalpi stretch and compare findings with the prominent researches.

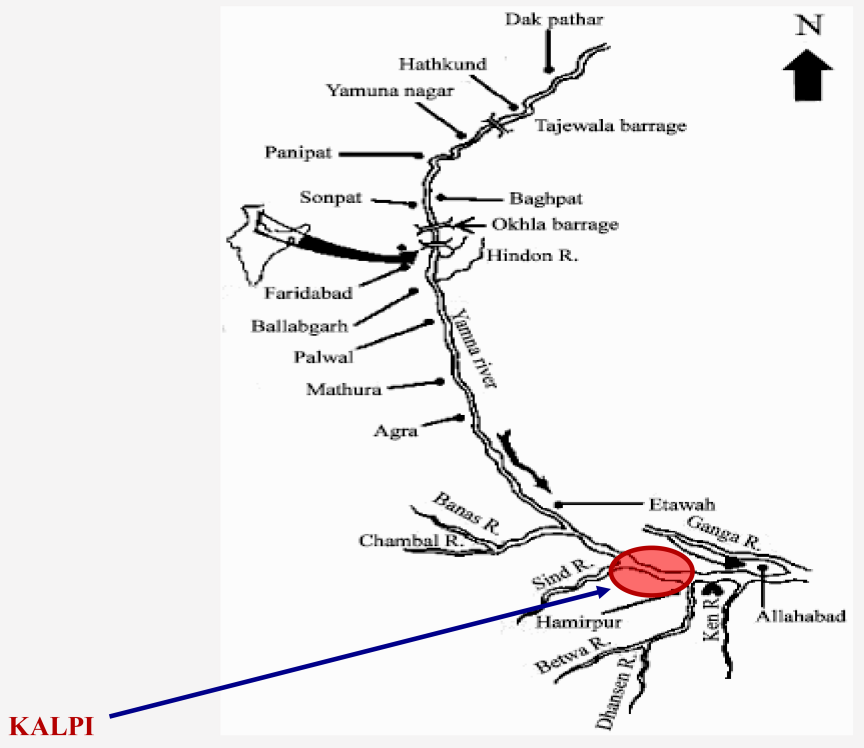

Fig 1. Location of study area in map of the Yamuna river. Source: CPCB, 2006

MATERIALS AND METHODS

Study area

The study was carried out at Kalpi stretch of the Yamuna river which is a historical city of district Jalaun of Uttar Pradesh and lies to the south east bank of Yamuna falls under 2607'14"N latitude to 79044' 59"E longitude with an elevation of 112 meters. 5km length of the Yamuna at Kalpi stretch from in front of Vyas Mandir (u/s) to Raid drain opening (d/s) was under consideration for this limnological study (Fig. 1).

Sampling and analysis

Four sampling sites named as S_1- in front of Vyas Mandir, S_2- Kila Ghat, S_3- Peela Ghat and S_4- after Raid drain opening were selected for the sampling purpose. The samples were collected monthly till one year from October 2013 to September 2014.Water temperature was measured by thermometer and pH was measured by pen pH meter at sampling site. Other parameters like Cond., Turb.,T.D.S., T.H., T.A.,Cl, SO_4, PO_4, NO_3, D.O., B.O.D.and C.O.D. were analyzed in the laboratory according to the standard methods (Adoni 1985,Trivedi and Goel 1986 and APHA 2005).Plankton samples were examined under high power microscope and identified up to species level with the help of standard books and monographs (Prescott 1962, Adoni 1985, Battish 1992).Aquatic macrophytes were collected from different types of habitate and identified up to species level with the help of pertinent literature.Fishes were identified up to species level with the help of standard books and monographs (Jhingran1992, Jayram 2010).

RESULTS AND DISCUSSION

Physico-chemical parameters

Observed selectedphy sico-chemical parameters were tabulated and analyzed to understand the physico-chemical characteristics of studied water sample by comparing with maximum permissible limit of W.H.O for drinking water (Table 1).

Water Temperature (W.T.) was in range between 15.5 0C to 31.5 0C and average temperature was 25.38 0C. It was suitable for the survival and growth of fish fauna.The pH value was in range from 7.60 to 8.70 with average value of 8.28. It was higher in most of the time than the permissible limit of WHO for drinking water.pH of Yamuna river was alkaline in nature. It was under the limit for fish culture (i.e., 6.0 to 9.0) and irrigation purpose (i.e., 5.5 to 9.0)(Irrigation Water Quality, MOE 1999). Conductivity was recorded in the range of 330 µS/cm to 1060 µS/cm and average value was 601.25 µS/cm.It was more than the drinking water limit of WHO.Value of turbidity was in range of 26.0 to 200 NTU. Mean value of turbidity was 83.58

Table 1. Physico-chemical parameters of the Yamuna river at Kalpi stretch and their comparison with drinking water limit of World Healh Organiztion (WHO 1999). Source: Kumar et al. 2016.

Sl. No.	Physico-chemical Parameters	Minimum	Maximum	Mean	Maximum permissible limit for drinking water prescibdby WHO
1.	Water Temp. (OC)	15.5	31.5	25.38	–
2.	pH	7.60	8.70	8.28	6.5—8.5
3.	Conductivity (µS/cm)	330	1060	601.25	300
4.	Turbidity (NTU)	26.0	200.0	83.58	5.0
5.	T. D. S.(mg/L)	458.0	675.0	564.58	250—600
6.	T. H. (mg/L)	84.5	148.9	111.48	500
7.	T. A. (mg/L)	91.5	215.6	173.92	200—600
8.	Cl (mg/L)	14.5	48.5	26.88	250—1000
9.	SO (mg/L)	11.05	29.75	22.25	250
10.	PO (mg/L)	0.52	1.74	0.82	0.5
11.	NO (mg/L)	0.38	4.6	1.26	50
12.	D. O. (mg/L)	6.0	8.53	7.45	2—6
13.	B. O. D. (mg/L)	3.25	12.00	7.71	3
14.	C.O.D. (mg/L)	10.85	26.80	21.2	10

Table 2. List of recorded phytoplankton in the Yamuna river at study area (Kalpi).

Chlorophyceae	
Genera	Species
1. *Ankistrodesmus*	*falcatus*
2. *Chlorella*	*vulgaris*
3. *Chlorococcum*	*infusionum*
4. *Cladophora*	*fracta*
5. *Cosmarium*	*tenue*
6. *Closterium*	sps.
7. *Hydrodictyon*	*reticulatum*
8. *Pediastrum*	*simplex*
Pediastrum	*tetras*
9. *Scenedesmus*	*quadricauda*
10. *Spirogyra*	*condensata*
11. *Stigeoclonium*	*tenue*

Euglenophyceae	
Genera	Species
1. *Eugelna*	*acus*
Euglena	*viridis*
2. *Phacus*	*caudatus*

Bacillariophyceae	
Genera	Species
1. *Cyclotella*	*meneghiniana*
2. *Melosira*	sps.
3. *Navicula*	*viridula*
4. *Nitzschia*	*angustata*
5. *Synedra*	*ulna*

Cyanophyceceae	
Genera	Species
1. *Anabaena*	*fertilissima*
2. *Lyngbya*	*gracilis*
Lyngbya	*magnifica*
Lyngbya	*spirulinoidus*
3. *Merisopedia*	*elegane*
Merismopedia	*punctata*
Merismopedia	*glauca*
4. *Microcysstis*	*aeruginosa*
5. *Nostoc*	sps.
6. *Oscillatoria*	*clorina*
Oscillatoria	*limosa*
Oscillatoria	subbrevis
Osillatoria	*tenuis*
7. *Phormidium*	*calciola*
Phormidium	*uncinatum*

NTU. Noticed turbidity value was found to greater than drinking water limit of WHO.Total Dissolved Solid (T.D.S.) was in range from 458 to 675 mg/L and average values was 564.58 mg/L. In most time, noticed T.D.S. value range was more than the limit recommended by WHO for drinking water. Recorded Total Hardness (T.H.) value in the range of 84.5 mg/L to 148.9 mg/L. Average of recorded hardness was 111.48 mg/L.Recorded hardness value was under the drinking water limit of WHO.Total Alkalinity (T.A.) was recorded in between 91.5 mg/L to 215.6 mg/L while average value was 173.92 mg/L. Noticed T.A. value was more than WHO recommended limit for drinking water only in half time. T.A. of the studied water was more than 100 mg/L in most time thus it was suitable for fish culture. Observed Chloride (Cl) was varied from 14.5 mg/L to 48.5 mg/L and mean value was 26.88 mg/L. It was under the limit of WHO for drinking water.Sulfate (SO_4) was in range of 11.05 mg/L to 29.75 mg/L. Average value of recorded sulfate was 22.25 mg/L. It was under the lower limit of WHO for drinking water. Phosphate (PO_4) was in the range of 0.52 mg/L to 1.74 mg/L. Average value of phosphate was 0.82 mg/L.It was beyond the permissible limit of drinking water as prescribed by WHO.Nitrate (NO_3) was recorded in range of 0.38 mg/L to 4.60 mg/L and average value was 1.26 mg/L. Recorded nitrate values was very low than the WHO limit of drinking water.Value of Dissolved Oxygen (D.O.) was ranged from 6.00 to 8.53 mg/L. Average value of D.O. was 7.45 mg/L.It was satisfactory to good in comparison of W.H.O. limit for drinking water. Thus it was also good for fish culture.Recorded Biochemical Oxygen Demand (B.O.D.) was in between 3.25 mg/L to 12.00 mg/L with the average value of 7.71 mg/L.It was more than the drinking water limit of B.O.D. prescribed by W.H.O. Chemical Oxygen Demand (C.O.D.) of the Yamuna water was varied in between 10.85 mg/L to 26.80 mg/L and average value was 21.2 mg/L. It was also more than thedrinking water limit of WHO.

Biological parameters

Observed biological parameters were tabulated and analyzed to understand the biological characteristics of studied water sample.

Table 3. List of pollution tolerant species of recorded phytoplanktonin order of decreasing emphasis (Palmer 1969).

1.	*Euglena viridis*	Euglenophyceae
2	*Oscillatorialimosa*	Cyanophyceae
3	*O. tenuis*	Cyanophyceae
4	*Scenedesmusquadricauda*	Chlorophyceae
5	*Stigeocloniumtenue*	Chlorophyceae
6	*Synedra ulna*	Bacillariophyceae
7	*Ankistrodesmusfalcatus*	Chlorophyceae
8	*Oscillatoriachlorina*	Cyanophyceae
9	*Chlorella vulgaris*	Chlorophyceae
10	*Cyclotellameneghinian*	Bacillariophyceae
11	*Euglena acus*	Euglenophyceae
12	*Phormidiumuncinatum*	Cyanophyceae
13	*Phacuscaudatus*	Euglenophyceae
14	*Naviculaviridula*	Bacillariophyceae
15	*Microcystisaeruginosa*	Cyanophyceae

Table 4. List of recorded aquatic macrophytes in study area (Kalpi).

Family	Genus	Species	Common Name
1. Azollaceae	*Azolla*	*pinnata*	masquito fern/ water fern
2. Ceratophyllaceae	*Ceratophyllum demersum*		Horwort/ coontail
3. Cyperaceae	*Cyperus*	*esculentus*	Sedge
4. Pontederiaceae	*Eichhornia crassipes*		Water hyacinth
5. Hydrocharitaceae	*Hydrilla*	*verticillata*	Oxygen weed
6. Lemnaceae	*Lemna*	*paucicostata*	Duck weed
7. Hydrocharitaceae (Najadaceae)	*Najas*	*minor*	Water velvet
8. Nymphaceae	*Nymphaea*	sps.	Water lily
9. Potamogetonaceae	*Potamogeton*	*crispus*	Curlyleaf pond weed
	Potamogeton	*pectinatus*	Sago pond weed
10.Lemnaceae	*Spirodella*	*polyrhiza*	Spirodella
11.Hydrocharitaceae	*Vallisneria*	*spiralis*	Eel grass

Phytoplankton

35 species of phytoplankton were recorded which belongsto four groups Chlorophyceae (12 species), Euglenophyceae (3 species), Bacillariophyceae (5 species) and Cyanophyceae (15 species) (Table 2). Chlorophyceae was dominated group over rest of the phytoplankton. By comparision of Palmer's algal index out of recorded 35 species of phytoplankton, 15 species like as *Euglena viridis, Oscillatorialimosa, O. tenuis, Scenedesmusquadricauda, Stigeocloniumtenue, Synedra ulna, Ankistrodesmusfalcatus, Oscillatoriachlorina, Chlorella vulgaris, Cyclotellameneghiniana, Euglena acus, Phormidiumuncinatum, Phacuscaudatus, NaviculaviridulaandMicrocystisaeruginosaare pollution tolerant* (Table 3). Presence of these species of algae indicates organic pollution in water bodies.

Macrophytes

12 species of macrophytes have been recorded which belongs to 11 genera of 8 families (Table 4) and three groups (a) *Submerged: Ceratophyllumdemersum, Hydrillaverticillata, Najas minor,Potamogeton-*

Table 5. List of recorded zooplankton in the Yamuna River at study area (Kalpi). Source: Kumar and Khare 2015

Protozoa		Rotifera		
Genera	Species			
1. *Arcella*	*dentata*		Genera	Species
2. *Paramecium*	*caudatum*	1.	*Asplanchna*	*intermedia*
3.*Vorticella*	*campanula*	2.	*Brachionus*	*calyciflorus*
Cladocera			*Brachionus*	*caudatus*
Genera	Species		*Brachionus*	*falcatus*
1. *Alona*	*rectangula*		*Brachionus*	*plicatilis*
2. *Bosmina*	*longirostris*		*Brachionus*	*quadridentatus*
3. *Ceriodaphnia*	*reticulata*		*Brachionus*	*rubens*
4. *Daphnia*	*carinata*	3.	*Filinia*	*longiseta*
5. *Moina*	*brachiata*	4.	*Keratella*	*cochlearis*
Copepoda			*Keratella*	*tropica*
Genera	Species	5.	*Philodina*	*citrina*
1. *Cyclops*	*bicuspidatus*	6.	*Polyarthra*	sps.
2. *Macrocylops*	*albidus*			

Table 6. List of recorded fishes of river Yamuna and their feeding habits.

	Fish	Species	Family	Ecological distribution	Feeding habits
1.	*Anabas*	*testudineus*	Anabantidae	Very Common	Entomophagous
2.	*Barilius*	*barna*	Cyprinidae	Very Rare	....
3.	*Catla*	*catla*	Cyprinidae	Very Common	Planktophagous
4.	*Chagunius*	*chagunio*	Cyprinidae	Rare	...
5.	*Channa*	*gachua*	Channidae	Rare	Carnivorous
6.	*Channa*	*marulius*	Channidae	Common	Carnivorous
7.	*Channa*	*punctatus*	Channidae	Very Common	Carnivorous
8.	*Cirrhinus*	*mrigala*	Cyprinidae	Very Common	Omnivorous
9.	*Cirrhinus*	*reba*	Cyprinidae	Very Rare	Carnivorous
10.	*Clarias*	*batrachus*	Clariidae	Rare	Carnivorous
11.	*Cyprinus*	*carpio*	Cyprinidae	Rare	Omnivorous
12.	*Esomus*	*danricus*	Cyprinidae	Very Rare	...
13.	*Eutropiichthys*	*vacha*	Schilbeidae	Common	...
14.	*Heteropneustes*	*fossilis*	Heteropneustidae	Rare	Omnivorous
15.	*Hypopthalmicthys*	*molitrix*	Cyprinidae	Rare	Planktophagous
16.	*Labeo*	*bata*	Cyprinidae	Rare	Herbivorous
17.	*Labeo*	*calbasu*	Cyprinidae	Very Common	Omnivorous
18.	*Labeo*	*gonius*	Cyprinidae	Very Rare	Planktophagous
19.	*Labeo*	*rohita*	Cyprinidae	Common	Herbivorous
20.	*Mastacembelus*	*armatus*	Mastacembelidae	Common	Carnivorous
21.	*Mystus*	*tengara*	Bagridae	Rare	Carnivorous
22.	*Mystus*	*seenghala*	Bagridae	Very Common	Carnivorous
23.	*Notopterus*	*chitala*	Notopteridae	Common	Carnivorous
24.	*Notopterus*	*notopterus*	Notopteridae	Common	Carnivorous
25.	*Ompok*	*bimaculatus*	Siluridae	Very Rare	.....
26.	*Oxygaster*	*bacaila*	Cyprinidae	Common	Omnivorous
27.	*Puntius*	*sarana*	Cyprinidae	Very Rare	Omnivorous
28.	*Rita*	*rita*	Bagridae	Common	Carnivorous
29.	*Wallago*	*attu*	Siluridae	Very Common	Carnivorous

crispus, P. pectinatus and Vallisneriaspiralis(b) *Floating:Azollapinnata, Eichhorniacrassipes,Lemnapaucicostata,Nymphaeasps*. and *Spirodellapolyrhiza*(c)Emergent:*Cyperusesculentus.Presence* of Eichhornea, *Potamogeton* and *Cyperusindicates* presence of high phosphate and nitrate in water bodies.

Zooplankton

22 species of zooplankton have been recorded which belonges to four groups like as Protozoa (3 species), Rotifera (12 species), Cladocera (5 species) and Copepoda (2 species) (Table 5). Among recorded zooplankton Rotifer's population was dominant which indicates organic pollution in studied water sample. Pollution indicator species like Brachionus sps. and Keratella sps. were recorded along with clean water *indicator* sps. like *Daphnia* sps. and *Cyclops* sps. Presence of Brachionuscalyciflorusis considered to be good indication of eutrofication (Sampaio et al. 2002).

Fishes

29 species of fishes of 10 families were identified in the Yamuna River at Kalpi stretch during course of study (Table 6). IIT(s) (2012) have been recorded 67 species in Auraiyya to Allahabad stretch of Yamuna River.Along with other 28 species of fishes Clariasbatrachus like pollution indicator fish was also recorded. Fishes from the family Cyprinidae dominates the other variety of fish species.

CONCLUSION

Comparing of recorded physico-chemical data with drinking water limit of WHOit is found that pH, Conductivity, Turbidity, TDS, PO_4, BOD, COD and mostly TA were beyond the drinking water limit while TH, Cl, SO_4 and NO_3were below the limit. D.O. was satisfactory to good codition. Recorded mostly physico-chemical parameters like water

temperature, pH, T.D.S., T.H., T.A., and D.O., were fit for fish culture and irrigation purpose.Occurrence of pollution tolerating15 species of phytoplankton like *Euglena viridis, Oscillatorialimosa, O. tenuis, Scenedesmusquadricauda, Stigeocloniumtenue, Synedra ulna, Ankistrodesmusfalcatus, O. chlorine, Chlorella vulgaris, Cyclotellameneghiniana, E. acus, Phormidiumuncinatum, Phacuscaudatus, Naviculaviridulaand Microcystisaeruginosa,*dominance of Rotifer's population inzooplankton, presence of pollution indicator zooplankton species like *Brachionus* sps. and *Keratella* sps.,occurrence of high phosphate and nitrate indicators macrophytes such as Eichhornea, Potamogeton and Cyperusand Clariasbatrachus like pollution indicator fish along with other clean water species show the sign of organic pollution.This limnological analysis clears that the water quality of Yamuna river at Kalpistretch was not fit for drinking purpose (i.e. moderately polluted) but it was satisfactory for fish culture and irrigation purpose, during the study period. Polluted water has a wide variety of effects on plant life. It not only harms plant growth but also allows plants to absorb dangerous chemicals and pass them on to animals. Water pollution from substances can disrupt photosynthesis in aquatic plants because when water is polluted, the capacity of water to dissolve gases such as carbon dioxide is negatively affected. Polluted water also affects the fishes severely and proves lethal to them. It can directly kill or harm fishes or reduce their reproduction rate or change the makeup of the fish' surroundings, killing off sources of food or causing plant or algae over growth that starve the fish of oxygen.

To maintain the river ecology and prestine status of this river following remedial measures should be apply-public awareness programs, adaptation of water harvesting system to reduce over exploitation of river water,segregation of domestic and industrial wastes then separate treatment and disposal system for both, all type of drainage should be diverted and treated in plants before discharge thentreated sewage water can be used for irrigation or aquaculture, disposal of all type of garbage, solid, semi solid waste into the river should be stopped, establishment of Combined Effluent Treatment Plant (C.E.T.P.) for small industries (paper industries of Kalpi) effluent treatment, establishment of some water pockets like pools in adjoining area of the river for washing cloths, cattle bath and idols immersion, agricultural runoff from crop lands might be checked by making boundary wall in surroundings of crop fields.

ACKNOWLEDGEMENT

I am gratefully thank to the principal and head of department of botany, Maharaja Government Autonomous P.G. College Chhatarpur, M.P. for providing lab facilities. I am also gratefully thank to Dr. P.K. Khare Professor, department of botany Maharaja Govt. Autonomous P.G. College Chhatarpur, M.P. for valuable guidance and support to this research program.

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