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Original Research Article

Soil microbiological indices of polluted soils of industrial belts of Jammu, India

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A B S T R A C T

Investigations were carried out in the Districts of Samba and Kathua of Jammu region with the twin objectives of identifying heavy metal toxicity areas around industrial belts and to assess the impact of the effect of heavy metals on biological properties of soil. The soils under study were was mostly sandy loam to clay loam Microbiological investigations revealed that a decrease in bacterial population in the different polluted samples was up to 31.19% (Dhiansar RWS-4) besides fungal population also showed a substantial variation from 30 to 74 % in district Samba. Amongst different heavy metals detected in soils near industrial belts of District Samba and district Kathua ,Cadmium (Cd) was not detected in soils of district Samba but contrastingly in soils of district Kathua it was observed in two production systems, viz. rice-wheat and vegetable production system varying between 0.78 to 5.11 and 0.0 to 3.8 µg g^{-1} respectively Soil respiration was also depressed (8.64CO_{2}.Cg^{-1}soil day^{-1} to 5.40 CO_{2}.Cg^{-1} soil day^{-1}) in polluted samples. Attempts were made to correlate the effectiveness of different ratios of microbial variables with heavy metal contaminations

Keywords

Heavy metals microbial biomass; carbon; nitrogen; Jammu.

Introduction

The anthropogenic activities responsible for the contamination of soil ecosystem results deterioration of soil health that has become a matter of concern. The contamination of soils by heavy metals leads to negative influence on soil characteristics and limit its productive and environmental functions. Cadmium, copper and zinc are among those heavy metals that are being released to the environment (Roane and Pepper, 2000).

Some heavy metals viz cobalt, chromium, nickel, iron , manganese and zinc have important role in the microbial metabolism and are involved in redox metabolism, enzymatic reactions, and regulating the osmotic balance (Hussein et al 2005) . Even at low concentrations of cadmium, mercury, lead etc are detrimental to the organisms However, at high levels both of the essential and non essential metals become toxic to the organisms.

Concern about soil health due to heavy metals toxicity to soil microbes and immobilization of pesticide in the immobilized form can persist for long time before its availability to living organisms including plants (Nannipieri *et al.* 1997). Heavy metals effect on soil microbial community involved in the biomediated process of organic matter degradation and mineralization (Castaldi *et al.* 2004). Heavy metals effect the microbial growth and allied biochemical activities and ultimately resulting in decreased biomass and microbial population (Roane and Pepper, 2000). Soil microbiological and biochemical properties are successfully and more effectively used to evaluate the soil contamination in comparison with the monitoring of the chemical and physical properties of soil (Nannipieri *et al.* 1997).

Materials and Methods

A comprehensive survey was conducted in order to evaluate soils from different locations near the industrial belts of district Samba and Kathua for heavy metals contamination (Cd, Pb, Ni, Fe and Zn) from industrial/ domestic effluents irrigation.

A modern industrial complex is established on the bank of river Basantar at Samba named as industrial growth centre Samba town (Plate 1) is situated at 32°.33´N and 75°.07´E lelevation 1184ft on range Shivalik hills alongside the national highway 1-A on the bank of river Basantar at a distance of 40 kms from Jammu city. Another industrial area is located in district Kathua (Plate 2) is situated at 32°.37´N and 75°.52´E. It has an area of 2440 sq km's. The entire area is hilly and sloppy with continuous tracts of undulating high ridges on lower sides of Jammu Pathankot National Highway, Jammu, India.

The study area was divided into the two major areas adjoining industrial belts of Samba and Kathua as per cropping system vis-a-vis locations specific; each with four sub locations in order to avoid biasness and to reduce sampling errors. Three preliminary samples for each location were taken from each sub location then composited to form one laboratory sample of that material for the particular sub location. Each sample was put in a separate polythene bag and labeled. A distance of about 500 m interval was used from one sampling site to another within the sub location. Collected samples were transferred to plastic bags, brought to Laboratory and prepared for the analyses. Sampling scheme is given in table 1

Soil samples for biochemical analysis were taken and made free of stones and plant residues and was then sieved (< 2 mm) and mixed uniformly. The water contents in soil samples were adjusted to 50 % of their water-holding capacity (WHC). The soil samples were stored in plastic bags at 4 ^{0}C prior to biochemical analysis. For soil physical and chemical analysis, a subsample of each soil was air-dried, ground to powder form and stored in the plastic bottles. All soil samples were analyzed in triplicate to minimize the error and the results are presented on oven dry weight basis.

Air dried soil (10 gm) was taken in 250 ml Erlenmeyer flask and was treated with 20 ml of extracting reagent (AB-DTPA) for extraction of heavy metals. The contents were shaken for 15 minutes. The filtrate through Whatman No.42 was stored in clean plastic bottles and analyzed for Pb, Cd, Cr, Ni, Zn, and Fe by (Soltanpour and

Workman, 1979) using atomic absorption spectrophotometer Model-Z2300; Hitachi Japan.

Colony forming units (CFU) of bacteria were determined by a plate dilution technique using soil extract agar for bacteria and Rose Bengal Streptomycin Agar for fungi (Martin 1950). Microbial biomass carbon (MBC) and Microbial biomass Nitrogen (MBN) were analyzed by using the chloroform fumigation-extraction method. Ten grams of soil sample was exposed to alcohol-free chloroform ($CHCl_3$) vapor in a vacuum desiccators containing soda-lime at 25±1 ^{0}C for 24 h. The fumigated soil was transferred into desiccators and residual $CHCl_3$ was removed from the fumigated soils by suction pump. The fumigated soil was extracted immediately following $CHCl_3$ removal by shaking for 30 minutes with 50 mL 0.5 M K_2SO_4. The un-fumigated 10 g soil (oven dry weight) was extracted at the time of fumigation commencement. Carbon concentration of fumigated and non fumigated soil sample were determined though oxidation with potassium dichromate and difference of carbon concentration of fumigated and nonfumigated samples was divided by recovery factor K_{EC} (Yao,2006). Soil respiration was determined by method given by Zibilsje, 1994.

Result and Discussion

Heavy metals status in soil

Soil samples from different production system district Samba (pH (1:2.5) 6.86 - 7.15, E.C: 0.08-0.17 dsm^{-1}, OC: 0.36-0.46%) and from that of Kathua (pH (1:2.5) 6.60-6.93, EC: 0.11-0.16 dsm$^{-1,}$, OC: 0.35-0.47%) were taken in the vicinity of industrial area of district Samba and district Kathua of J and K state . Soil samples from Samba (table2) indicated that Iron content varied between 1.28 to 29.21, 1.70 to 26.76, 14.31 to 30.23and 5.14 to 23.69 µg g^{-1}of soil in the surface soil of rice-wheat production system, maize-wheat production system, pasture system and vegetable production system respectively ,whereas Zinc content in the same soils of district Samba showed the maximum value in pasture system (1.85 µg g^{-1}of soil) followed by maize-wheat production system (0.80 µg g^{-1}of soil), rice-wheat production system (0.60 µg g^{-1}of soil) and Vegetable production system (0.51 µg g^{-1}of soil) . Lead (Pb) content was detected up to 383.66 µg g^{-1} in the surface soil of rice-wheat production system and varied between 0.35 to 0.65 and 0.40 to 300 µg g^{-1}soil in pasture system and vegetable production system, respectively.

Iron in the soils of district Kathua was found to vary between 14.68 to 34.79, 0.64 to 19.06, 14.49 to 23.60 and 25.74 to 34.35 µg g^{-1} of soil in the soils of rice-wheat production system, maize-wheat production system, pasture system and vegetable production system, respectively and in pasture system highest mean zinc (Zn) concentration was 2.14 µg g^{-1}of soil and the lowest in vegetable production system (0.27 µg g^{-1}of soil) .Cadmium (Cd) was not detected in soils of district Samba but contrastingly in soils of district Kathua it was observed in two production systems, viz. rice-wheat and vegetable production system varying between (0.78 to 5.11 and 0.0 to 3.8 µg g^{-1} respectively) in the soils near the industrial areas .Soils of district Kathua showed a maximum Lead (Pb) content in vegetable production system up to 369.2 µg g^{-1}of soil followed by rice-wheat and maize-wheat production system(56.66 and 6.51 µg g^{-1}of soil, respectively). Pasture system soils had the lowest Pb content (4.57 µg g^{-1}of soil) (table 3).

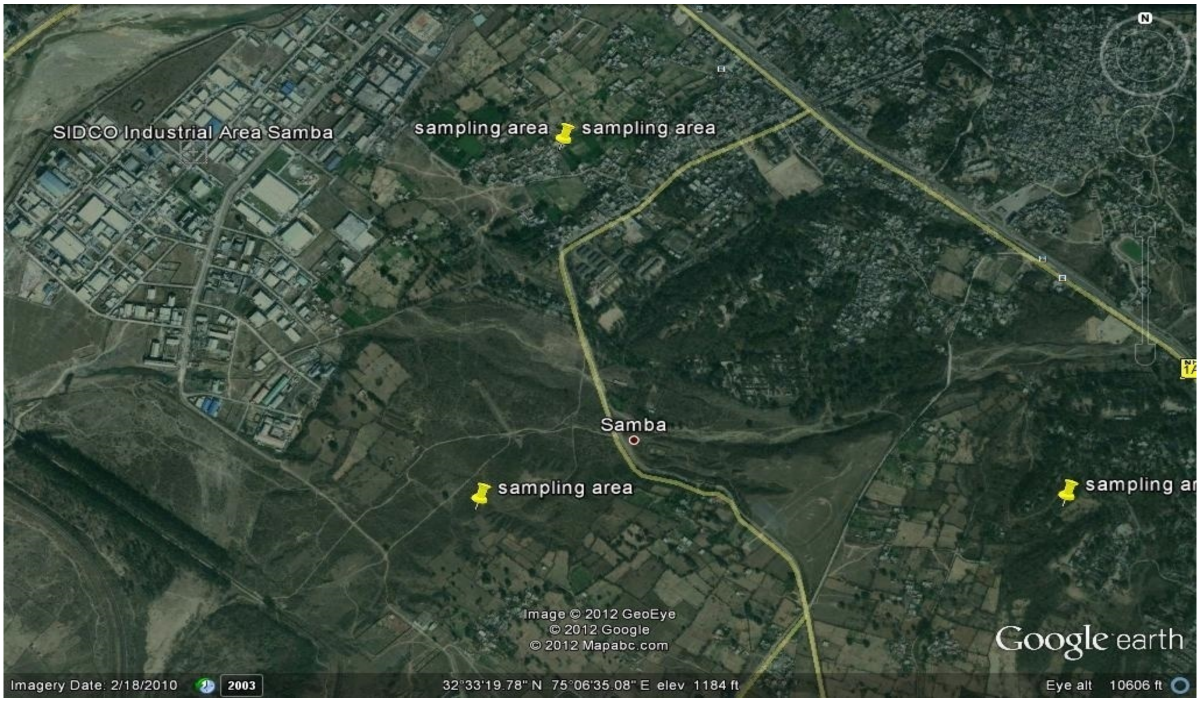

Fig.1 Satellite image of sampling area (Samba)

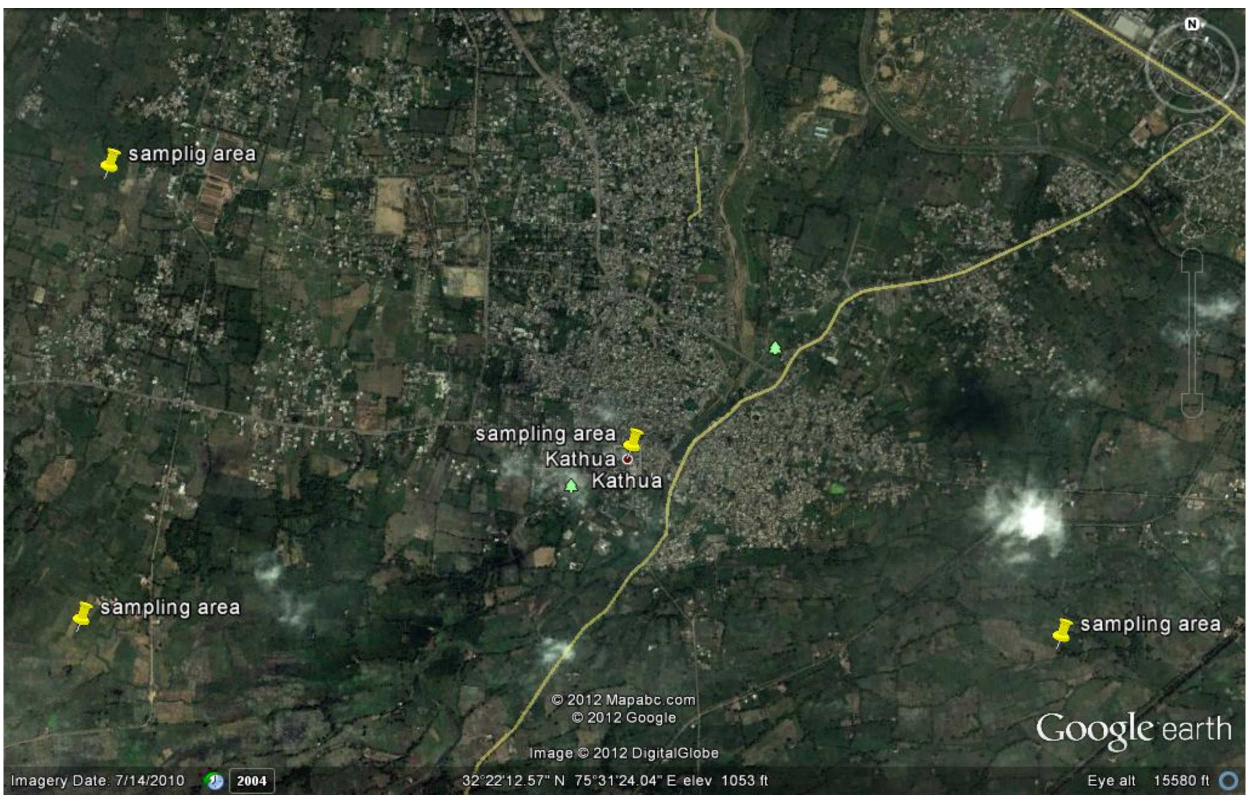

Fig.2 Satellite image of sampling area (Kathua)

Table.1 Soil sampling scheme

District Samba			
Rice-wheat system	**Maize-wheat system**	**Pasture system**	**Vegetable system**
Dhiansar RWS- 1	Rakh dhiansar MWS-1	Kothay PS-1	Dhiansar VS-1
Dhiansar RWS- 2	Tanda MWS-1	Dhiansar PS-1	Dhiansar VS-2
Dhiansar RWS- 3	Kothay MWS-1	Dhiansar PS-2	Dhiansar VS-3
Dhiansar RWS- 4	Tanda MWS-2		Dhiansar VS-4
Kartholy RWS-1			
Channi RWS-1			
Tanda RWS-1			
Tanda RWS-2			
Tanda RWS-3			
Tanda RWS-4			
District Kathua			
Traftujwal RWS-1	Govindsar MWS-1	Kathua PS-1	Bajwal VS-1
Traftujwal RWS-2	Govindsar MWS-1	Kathua PS-2	Bajwal VS-2
Traftujwal RWS-3	Govindsar MWS-1	Kathua PS-3	Bajwal VS-3
Traftujwal RWS-4	Govindsar MWS-1		Bajwal VS-4
Bajwal RWS-1			
Bajwal RWS-2			

Table.2 Heavy metals concentration in soils under different production systems adjoining industrial areas in Samba

Location	**Heavy metal concentration (µg g^{-1})**				
	Fe	**Zn**	**Cd**	**Pb**	**Ni**
Rice-wheat production System (RWS)					
Range	1.28-29.21	0.100-2.240	ND	0.0-383.66	ND
Mean	12.806	0.60	ND	70.11	ND
Maize-wheat production System (MWS)					
Range	1.70-26.76	0.11-2.06	ND	ND	ND
Mean	14.75	0.80	ND	ND	ND
Pasture System (PS)					
Range	14.31-30.23	0.82-2.70	ND	0.35-0.65	ND
Mean	**23.83**	**1.85**	ND	0.33	ND
Vegetable production system (VS)					
Range	5.14-23.69	0.36-0.88	ND	0.401-300.85	ND
Mean	**13.99**	**0.51**	ND	75.49	ND

Table.3 Heavy metals concentration in soils under different production systems adjoining industrial area in district Kathua

Location	Heavy metal concentration (µg g^{-1})				
	Fe	**Zn**	**Cd**	**Pb**	**Ni**
Rice-wheat production System (RWS)					
Range	14.68-34.79	0.2-0.45	0-5.11	0-313.73	ND
Mean	**27.87**	**0.33**	1.54	**56.66**	ND
Maize-wheat production System (MWS)					
Range	0.64-19.06	0.29-2.4	ND	0.1-24.48	ND
Mean	9.135	**1.06**	ND	6.517	ND
Pasture System (PS)					
Range	14.49-23.60	1.35-2.65	ND	0.917-10.680	ND
Mean	19.76	2.14	ND	4.57	ND
Vegetable production system (VS)					
Range	25.74-34.35	0.11-0.33	0.0-3.8	ND-369.2	ND
Mean	32.01	**0.27**	ND	181.31	ND

Table.4 Heavy metals concentration in irrigation channels in different production systems adjoining industrial area in district Samba

Location	Heavy metal concentration (µg g^{-1})				
	Fe	**Zn**	**Cd**	**Pb**	**Ni**
Rice-wheat production System (RWS)					
Range	0.0020-0.0051	0.75-0.93	ND	0-313.73	ND
Mean	**0.003**	**0.84**	ND	**1.62**	ND
Maize-wheat production System (MWS)					
Range	ND-0.001	1.11-1.62	ND	0.014-0.018	ND
Mean	0.0005	**1.36**	ND	0.016	ND
Pasture System (PS)					
Range	0.006-0.0071	0.41-0.83	ND	0.003-0.229	ND
Mean	0.0065	0.62	ND	0.116	ND
Vegetable production system (VS)					
Range	0.001-0.0081	1.01-1.34	ND	0.272-0.358	ND
Mean	0.0045	**1.17**	ND	0.315	ND

Microbiological Indicators

Comparing the soils affected by pollutants with the soils free of pollutants, a decrease in bacterial population in the different polluted samples was 4.08% (Tanda RWS-1) to 31.19% (Dhiansar RWS-4). Fungal population also showed a substantial decrease from 30 to 74 % in district Samba. Maize-wheat system at Rakh dhiansar MWS-1, Tanda MWS-1, Kothay MWS-1, Tanda MWS-2 showed decrease in bacterial population and fungal population by 5% to 27% and 37 to 46% respectively with a concomitant decrease in MBN and MBC from 4 to 42 % and 8 to 37 %. Similarly in Kathua contaminated soils under rice wheat, maize-wheat , pasture and vegetable production systems showed decrease of bacterial populations from 3.6 to 16.9 %,7.2 to 26.4%, 2.4 to 4.6 %, 3.1 to 5.3 %. and that of fungal populations from 30 to 56.6 %, 20 to 36, %. 10 to 20%, 9.5 to 22.8 %(Table 6). Microbial biomass nitrogen (MBN), microbial biomass carbon (MBC) and soil respiration also showed significant depression from 6 to 83 %, 8 to 43%, and 9 to 40% respectively in rice-wheat production system. Significant depression in soil respiration in polluted samples was also observed. Similarly pasture system and vegetable system was also affected (Fig. 1) in the soils of Samba, where as in the contaminated soils of district Kathua under different production systems marked a significant decrease in Microbial biomass nitrogen (MBN), microbial biomass carbon (MBC) and soil respiration up to 78.8, 32.6 and 82.8 % respectively (fig 3 & fig 4).

Microbial biomass carbon/ nitrogen (MBC/MBN) ratio under rice-wheat production system at different locations of district Samba varied between 20.47 to 112.01 where as ratio of MBC to SOC in the systems under different localities varied from 0.03 to 0.06 (Fig. 2). Ratio of soil respiration/biomass carbon showed the increase from 0.03 to 0.06 compared to non polluted one (Fig. 2). Ratio of biomass carbon/ nitrogen (MBC/MBN) in maize wheat production system in the localities of of Rakh dhiansar MWS-1, Tanda MWS-1 and Kothay MWS-1 varied between 34.57 to 64.53 where as in the same localities ratio of MBC to SOC varied between 0.057 to 0.231(Fig.2). Sol respiration / biomass carbon in the same localities showed the difference of 0.2 units in the pasture system. Ratio of MBC to SOC varied from 0.03 to 0.045 where as ratio of soil respiration / MBC showed a 0.1 unit change in soil respiration (fig.2).

Correlations worked out for different microbial variable in rice wheat production system showed that there is a positive correlation between MBC and soil respiration and negative correlation with MBC/MBN. Significant correlation exists between ratio of MBC and SOC to MBC ($r = 0.846^{**}$). Presence of Iron in the soils shows negative correlation with the soil pH and also holds negative correlation with MBN. It is evident that with the increase of iron there is decrease of MBN because of low pH of soils. In maize wheat production system negative correlation was observed between MBN and ratio between MBC and MBN($r = -0.941^{**}$), and a significant positive correlation between ratio of microbial biomass carbon / SOC and MBC ($r = 0.582^{*}$) .This shows that increase in soil organic carbon leads to increase in MBC. A strong correlation between soil respiration / MBC and soil respiration($r = 0.714^{*}$) revealed that more the MBC more is the soil respiration but in some soils presence of lead decrease soil respiration. In pasture system, soil

Table.5 Heavy metals concentration in water under different production systems in district Kathua

Location	**Heavy metal concentration (µg g^{-1})**				
	Fe	**Zn**	**Cd**	**Pb**	**Ni**
Rice-wheat production System (RWS)					
Range	0.0020-0.0051	0.75-0.93	ND	0-313.73	ND
Mean	**0.003**	**0.84**	ND	**1.62**	ND
Maize-wheat production System (MWS)					
Range	ND-0.001	1.11-1.62	ND	0.014-0.018	ND
Mean	0.0005	**1.36**	ND	0.016	ND
Pasture System (PS)					
Range	0.006-0.0071	0.41-0.83	ND	0.003-0.229	ND
Mean	0.0065	0.62	ND	0.116	ND
Vegetable production system (VS)					
Range	0.001-0.0081	1.01-1.34	ND	0.272-0.358	ND
Mean	0.0045	**1.17**	ND	0.315	ND

Table.6 Microbial variables of different soils of district Samba & Kathua

Location	**Samba**		**Kathua**	
	CFU B (g^{-1} dry soil.)	CFU F (g^{-1} dry soil.)	CFU B (g^{-1} dry soil.)	CFU F (g^{-1} dry soil.)
Rice-wheat production System (RWS)				
Range	$23.6\text{-}32.9\times10^6$	$1.1\text{-}3\times10^2$	$29.8\text{-}34.6\times10^6$	$0.9\text{-}2.1\times10^2$
Mean	28.1×10^6	1.73×10^2	32.56×10^6	1.42×10^2
Maize-wheat production System (MWS				
Range	$24.2\text{-}32.6\times10^6$	$1.7\text{-}2\times10^2$	$24.2\text{-}30.5\times10^6$	$1.6\text{-}2\times10^2$
Mean	27.28×10^6	1.88×10^2	28.08×10^6	1.76×10^2
Pasture System (PS)				
Range	$22.4\text{-}26.6\times10^6$	$1.5\text{-}1.8\times10^2$	$31\text{-}31.7\times10^6$	$1.6\text{-}1.8\times10^2$
Mean	24.78×10^6	1.64×10^2	31.36×10^6	1.7×10^2
Vegetable production system (VS)				
Range	$23.4\text{-}24.6\times10^6$	$1.3\text{-}1.6\times10^2$	$33.3\text{-}34.1\times10^6$	$1.62\text{-}1.9\times10^2$
Mean	24.1×10^6	1.45×10^2	33.71×10^6	1.74×10^2

Figure.1 Microbial indices in different production systems of district Samba

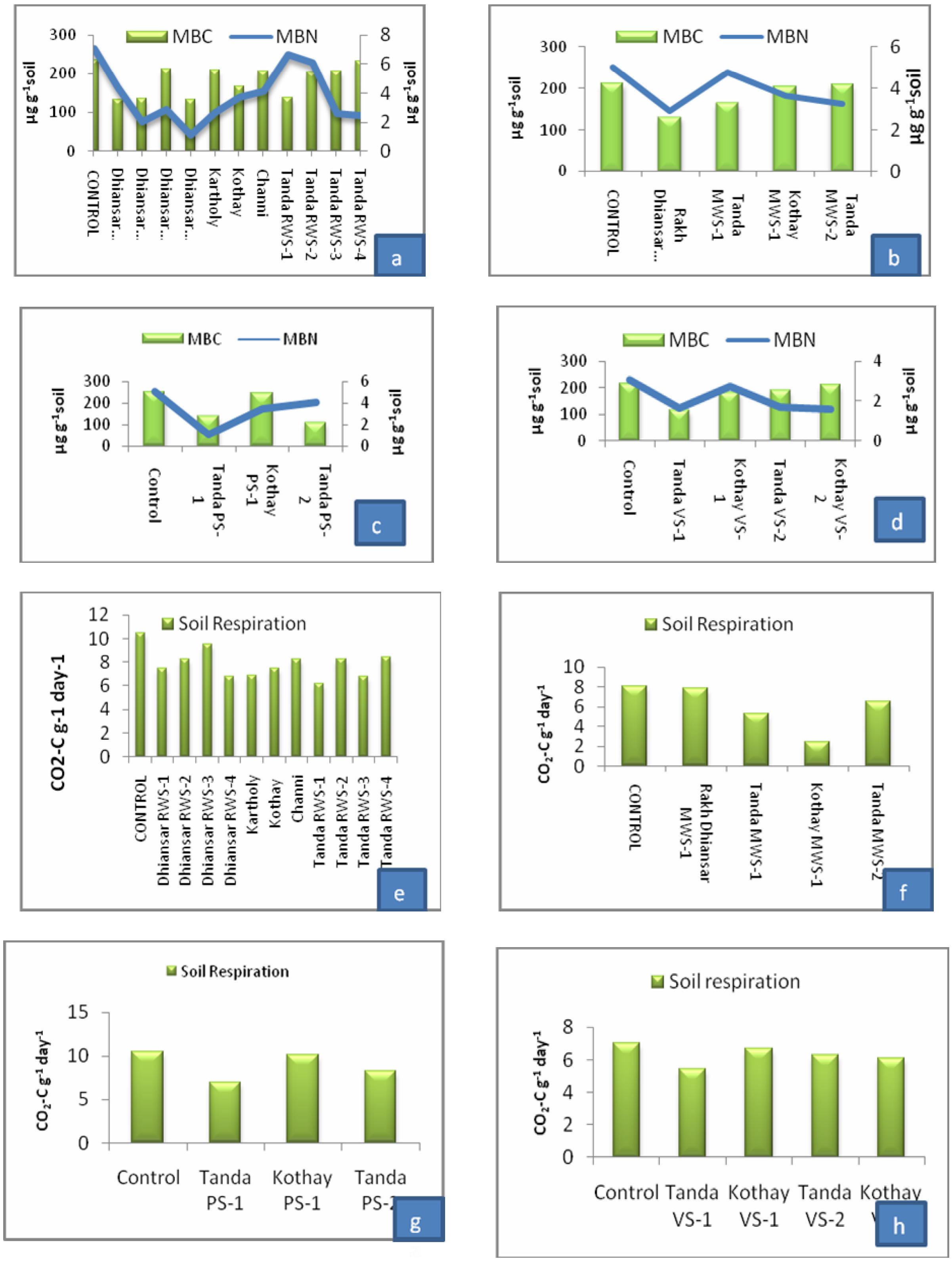

Figure.2 Microbial indices in different production systems of district Kathua

Figure.3 Microbial indices in different production systems of district Samba

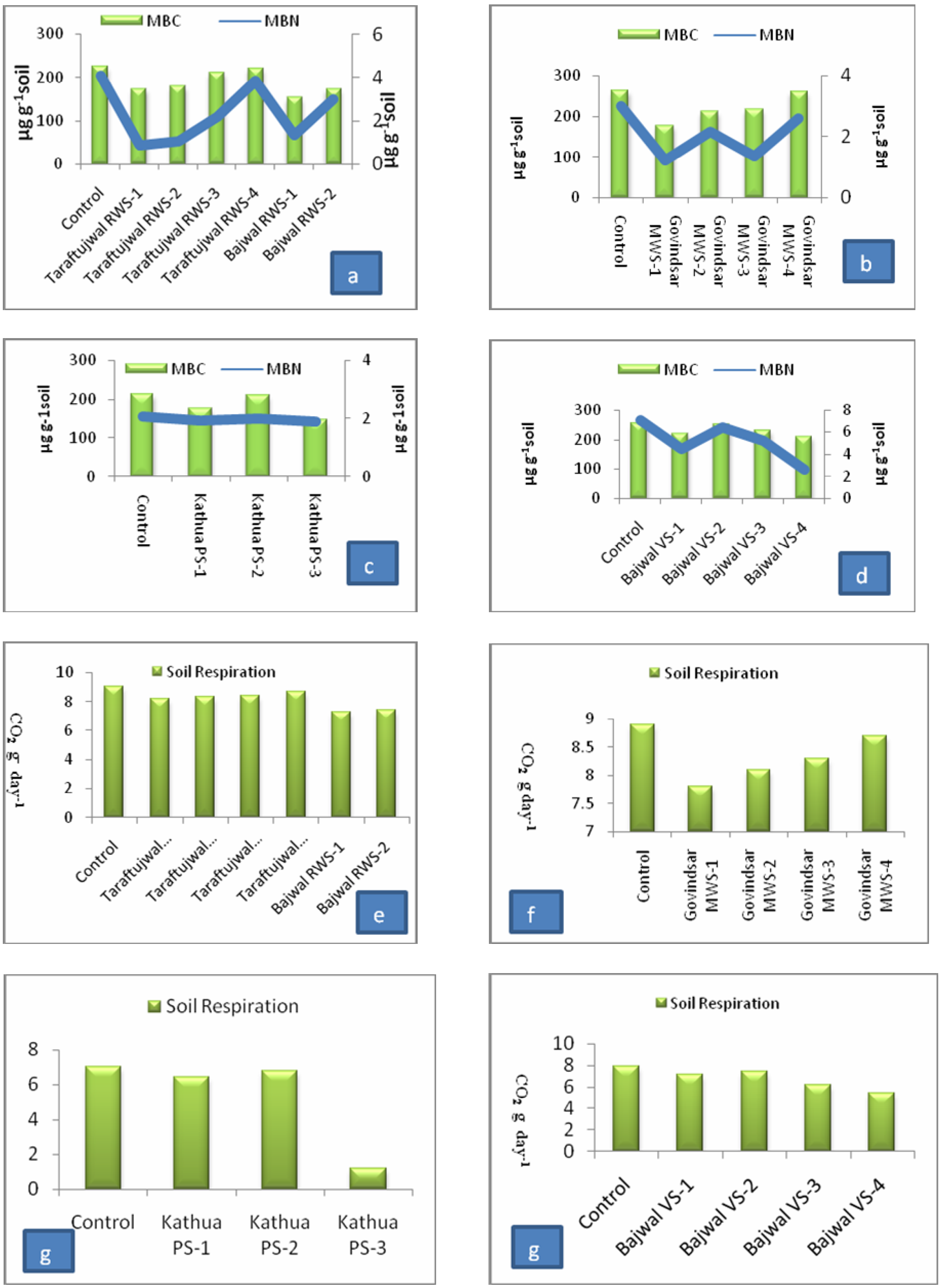

Figure.4 Microbial indices in different production systems of district Kathua

respiration is increased by the presence of more available N (r= 0.860*) where as the ratio of MBC / MBN shows a negative correlation with the MBN (r = - 0.913*). Soil respiration has shown negative increase with the MBC (0.971**).The presence of a zinc (Zn) in the pasture soils has shown a positive effect on the fungal population(r = 0.886*) where as in vegetable production system persistence of iron (Fe) in these soils have a positive significant correlation with bacteria and the presence of cadmium (Cd) in soils has shown a depressive effect on bacterial population in vegetable production system. (r= -0.383*), where as the fungal population is showing a positive correlation with cadmium displaying no impact of cadmium concentration on that of fungal population, whereas, no other parameter except for soil respiration is affected by Cd concentration.

Amongst the heavy metals, lead (Pb) was found to be slightly higher than the permissible limits (as per European Union standards, 2002) in two locations (Dhiansar RWS-2 and Kartholy RWS-1) representing rice-wheat production system and one location (Dhiansar VS-4) representing vegetable production systems in district Samba of Jammu and Kashmir. This may be attributed to the use of contaminated irrigation channel (Table 4) by industries which are evidenced from the water samples taken from the irrigation source being diverted to rice-wheat and vegetable systems for irrigation. In maize-wheat and pasture system, no such contamination was noticed owing to a limited irrigation to maize crop and no irrigation to pastures. Besides, the maize fields were comparatively away from the source of irrigation.

In district Kathua, Lead and Cadmium concentration, above the permissible limits (as per EU standards) was detected in soil at a few locations from rice-wheat and vegetable production systems due to the use of irrigation water contaminated by industries. Several research workers (Gutierrez *et al*. (2008), Rubio *et al*. (2004), Holguin *et al*. (2006) and Gutierrez and Borrego (1999) reported increased heavy metal concentrations in soil irrigated by polluted water. Similarly Tyler *et al*, 1972 have reported accumulation of Pb in soils distant from the source. In some sols, low Pb concentration may be because of tendency of this heavy metal to decrease with the depth (Miller and Friedland (1994,) as soil colloidal particles facilitate the Pb movement from upper to lower horizons. Possibilities of more lead concentration in lower layer can not be ruled out because of some geochemical processes like redox equlibria, adsorption/desorption, precipitation/ dissolution, and complexation/ chelation control lead mobility in the soil ecosystem.

All measured soil microbial indices were told upon by heavy metal concentrations. Total bacterial and fungal population decreased with increasing heavy metal concentrations (Table 3 and 4). Soil pollution stresses sensitive microorganisms and changes the diversity of soil microflora (Zaguralskaya 1997). The decrease in microbial density by heavy metal contamination at the different sites in the rice-wheat, maize-wheat, pasture and vegetable production system under study, is in agreement with Kikovic (1997). Total colony forming unit (CFU) represents the whole community of bacteria which was observed more in control (Uncontaminated soils) than in polluted soils. Some studies have also shown an increase in the fungal population proportion compared to bacteria in heavy metal contaminated soil (Hiroki, 1992; Kelly and Tate, 1998) which was not akin to the observations made in the present investigation where in at certain locations there is negative correlation of heavy metal with fungi. The decrease in population may be because microorganisms in soil under heavy metal stress divert energy from growth to cell maintenance functions (Killham, 1985).

Microbial biomass is a sensitive parameter that can be used as an indicator of changes in organic matter composition (Brookes 1995). A negative correlation was observed between MBC and presence of heavy metals in soils under rice-wheat production system. In present investigation inhibition of biomass C was observed up to 43% (rice-wheat production system), 37% (maize-wheat production system),55%(pasture system) and 46% (vegetable production system) in district Samba and 25%(rice-wheat production system) 32% (maize-wheat production system),31%(pasture system) and 16% (vegetable production system) in district Kathua (fig 3) which is lesser than that observed by Dias *et al.* 1998 (80 % reduction in biomass) and present investigation is somewhat comparable to observations made by Smejkalova *et al.* (2003) who reported an inhibition of soil MBC up to 50 % in soil contaminated with heavy metals (Pb, Cd and Zn) as compared to uncontaminated . Reduction in microbial biomass from metal exposure in the present investigation may be attributed to instantaneous death of microbial cells or disorder of important functions and change in population size and in viability or competitive ability of soil microorganisms (Giller *et al*. 1998).

Soil respiration was observed (fig1) depressed up to 40% (rice-wheat production system), 70% (maize-wheat production system), 34 % (pasture system) and 42% (vegetable production system) in district Samba and 18% (rice-wheat production system) 12% (maize-wheat production system),82% (pasture system) and 31% (vegetable production system) in district Kathua (fig 3) in the present investigation. Micro-organisms in less polluted soils use a higher amount of consumed carbon for assimilation and a smaller part is released as carbon dioxide (CO_2) in dissimilation processes. In contaminated soils, micro-organism needs more energy to survive in unfavorable conditions. Therefore, a higher portion of consumed carbon is released as CO_2 and a smaller part is built into organic components. Potential respiration was higher in less contaminated soils than in soils near the source of contamination.

The lower MBC: SOC ratio in contaminated soils (fig 2 & 4) in the present studies is because of microbial communities are in close contact with soil microenvironments, and therefore are easily subjected to change following alteration of soil chemical properties (Corstanje *et al.*, 2007) because of alteration in soil microenvironments likely to affect the microbial community structure and function, which can be described by the changes in microbial parameters such as respiratory capacities, microbial biomass and extracellular enzymatic activities (Castillo and Wright, 2008).Correlation coefficient worked out further confirmed a close link between heavy metals and microbial characteristics .A present investigation shows a stronger correlations between MBC and MBN with available heavy metals that demonstrate that toxicities to soil microorganisms are linked directly to heavy metals availability

(Wang *et al.*, 2007), and thus MBC and MBN might be used as sensitive indicators of the soil pollutions by heavy metals. The results were inconsistent with the reports of Wang *et al*. (2009) who observed that soil MBC did not correlate with heavy metals and can not be proposed as sensitive indicator for evaluating the environmental effects of heavy metal pollution. However, reduced MBC, MBN and MBP did not mean decreased diversity of soil microorganisms, because tolerant genotypes of some microorganisms with a high 'evolutionary potential' may sometimes develop within a few years (Tyler *et al*., 1989).

In present investigation, significantly negative correlations between certain microbial indices and heavy metals indicated the reduced activities of microorganisms with increasing heavy metals content, which have been well documented in previous reports (Renella *et al*., 2003, 2005; Liao and Xie, 2007; Wang *et al.*, 2007; Zhang *et al.*, 2008; Papa *et al*., 2009). Decrease in microbial biomass C and N in the present investigation in contaminated soils is for the reason that microorganisms need more energy to survive in unfavorable conditions due to which a higher percentage of energy is lost, and less carbon (C), nitrogen (N) and phosphorus (P) are built into organic components (Mikanova, 2006).

Metals complexed to soil organic matter may offer it some protection from microbial degradation (Hattori, 1996; Post and Beeby, 1996) but are less likely to exert a direct toxic effect on soil biology. Differences in metal content in different soils seems to be due the variability of organic matter in soils under investigation that might be expected to explain some of the variation in microbial responses obtained. Cd has less affinity for soil organic matter than Zn (Balabane et al., 1999) and has the lowest *K*d of any of the metals investigated. On the basis of published *K*d values (e.g. Sheppard and Thibault, 1990), Pb would be expected to behave similarly to Cu. and high levels of Pb in soils may decrease microbial biomass, meaning that the toxicity of metal manifest in set of biochemical reactions occurring in the soil environment (Stuczynskiel *et al* 2003, Tejada *et al* 2007, Marzadori *et al* 1996). Accordingly, plant productivity and microbiological communities in the soil environment decrease (Guiller *et al* 1998).

A present investigation beckons that soil microbial indices could serve as a good indicator of soil health, as shown uder different cropping system under the influence of contaminated irrigation , with considerable variance to the land management practices and the landscape gradient. Microbial biomass is a sensitive parameter and can be used as an indicator of changes in soil health contaminated by heavy metals. Quotients and ratios of two variables could be more useful than individual indicators (Schloter et al., 2003). A commonly used ratio is the metabolic quotient *q*CO2, a ratio of basal respiration and microbial biomass although this quotient should indicate changes in the metabolically active proportion of soil microbes and has been used as a measure of general stress, it has also been reported to infer ecosystem immaturity or substrate addition (Wardle & Ghani, 1995; Winding et al., 2005). Furthermore, the soil microbial communities correlated positively to some essential soil properties, of the sampled area.This establishes the possibility that other extrinsic factors that shall influence productivity. Future research should monitor the direction of shift in the microbial communities' structures and compositions over a long-term cropping system, as well as a progressive evaluation of the soil properties in theses problematic areas.

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