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IMPACT OF CETP EFFLUENTS ON CROPS AND GROUND WATER QUALITY OF JAJMAU AREA, KANPUR, UTTAR PRADESH, INDIA

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Abstract

The present study was carried out to assess the impact of waste water from sewage treatment plants (STPs) and Common Effluent treatment plant (CETP) in Jajmau, Kanpur on ground water, agriculture and environmental quality in the receiving areas around the Villages of Jajmau. Objective of the study was determining the extent of groundwater pollution and distribution pattern of heavy metals on vegetables caused by effluent of STPs and CETPs. Groundwater samples were collected during summer season of 2015 from hand pump of different villages of industrial area as well as control area and were analyzed for the physicochemical parameters and heavy metals like chromium Lead and Arsenic. Along with this, raw, treated and mixed treated wastewater samples were collected from the inlet and outlet points of the plants in summer season June 2015 and vegetable samples collected from 2015-2016. The comparison of the data of physicochemical properties of industrial area and control area showed that TDS, hardness and salt, Chromium content were found high in ground water of industrial area. The ground water of industrial area is not suitable for drinking as it contains high concentration of TDS, Hardness, Salt and chromium were found beyond the limits. It's only suitable for irrigation purposes, but in control area TDS and other parameters were under the limits. Polluted water is due to the recharge of partially treated effluent discharged by industries into open drains. The Average range of TDS hardness and salt were 473.66-2733.66 mg/l, 55.3-353.0 mg/l and 21.6-832.66 mg/l and other parameters like Ca, Mg, alkalinity, NO_3, SO_4 are also found in high levels. The use of chemicals, such as sodium chloride, sodium sulphate, chromium sulphate etc. during the tanning processes is the major reason for the high concentration of major ions and chromium in groundwater. Heavy metals mainly Cr, As, Pb, the average range were 0-0.36 mg/l, Arsenic 0-0.005 mg/l and Pb 0-0.0056 mg/l. As and Pb was found below the detection limits. On vegetables, the critical levels of the heavy metals like Cr, Fe, Mn and Zn also found in high concentration where effluent is using for agricultural crop. The Cr range was found between 0.19-18.46µg/g, Fe found between 87.07-841.2 µg/g, Zn found between 50.4-190.67, Mn found between 2.34-55 µg/g. Maximum Cr found on Suagrcane, Fe, Zn & Mn were found on black mustard. Hence it is important to regulate the industries and also take measures to reduce the total dissolved solids in the treated effluent before disposal. The groundwater quality of this region can also be improved by adopting rainwater harvesting thereby increasing groundwater recharge and also improves the quality of vegetables.

Keywords : Ground water, industrial waste water, physicochemical parameters, vegetable, heavy metals, correlation.

Introduction

Contamination caused by natural process or by human activities is serious ecological problem. Contamination of water as well as soil by toxic metals and several other sources is a serious concern in environmental perspective for safe zone in agriculture. Water from beneath the ground has been exploited for domestic use, livestock and irrigation since the earliest times. Long term irrigation can induce changes in the quality of soil and water. Due to this pollution load sustained over long periods. Water is drawn from the ground for a variety of uses, principally community water supply, farming (both livestock and irigated cultivation) and industrial processes (Chilton, 1996). Ground water has excellent natural quality usually free from pathogens, colour and turbidity and can be consumed directly without treatment (Saleem *et al.*, 2012). Groundwater is an essential and natural source of our life support system. It is required for most human activities like drinking, cooking, bathing, washing, agriculture, industry, recreation, navigation and fisheries. It is a major source for drinking purpose. In India, most of the population is dependent on ground water as the only source of drinking water supply (Murhekar, 2011).

Ground water has unique features which render it particularly suitable for public water supply. Ground water is used for domestic, agriculture and industrial purposes in most part of the world (Karunakaran *et al*., 2009).

In recent years, the increasing threat to groundwater quality due to human activity has become the matter of great concern. Now a days the ground water potential and its quality level in major cities and urban centres is getting deteriorated due to the explosion of population, urbanization, industrialization ,failure of monsoon and improper management of rain water (Arya *et al*., 2011). Not only ground water, soil is also contaminated by human and industrial activities due to dumping of solid waste and industrial effluent. Contamination of soil by toxic metals is a serious concern in environment perspective for safe rational utilization in agriculture. Heavy metal pollution is a menace to our environment as they are for most contaminating agent of our food supply especially vegetables (Chauhan and Chauhan, 2014). Waste water is being used for the irrigation of edible plants and is a matter of concern due to the presence of pollutants particularly toxic metals (Barman *et al*., 2000). The overexploitation of groundwater in some parts of the country induces water quality degradation (Mondal *et al*., 2005). India accounts for 2.2% of the global land and 4% of the world water resources and 16% of the world population. It is estimated that one third of the world's population use groundwater for drinking (Pawari and Pawande, 2015). Contamination of drinking water may occur by percolation of toxics through the soil to ground water (Khan and Prateek, 2012). Groundwater chemistry, in turn, depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and inputs from sources other than water–rock interaction (Domenico, 1972; Singh *et al*., 2011). Rapid urbanization and industrialization in India has resulted in deep increase of generation of waste. Due to lack of resources and awareness, waste is not properly treated and disposed. The problem is more crucial in large cities due to cluster of industries. But now water as resource is under relentless pressure due to population growth, rapid urbanization, large scale industrialization and environmental concern (Rai and Pal, 2002). During past few decades, the ground water and soil is being contaminated giving rise to health problems and epidemics. Carelessness in safe dumping of toxic solid waste is also one of the challenges for food chain. The solid waste generated from industries is being dumped near the factories, is subjected to reaction with percolating rain water, and reaches the ground water level. Which create the problem of ground water pollution in several part of the country. Safe drinking water is primary need of every human being. Pollution of ground water has been growing increasingly in several parts of India (Ramesh and Thirumangai, 2014). Both surface and subsurface water sources are getting polluted due to developmental activities (Chandra *et al*., 2014). It is important to know the quality of ground water because it is the major factor which decides its suitability for domestic, agricultural and industrial purposes (Raju *et al*., 2009). Industries are responsible for water pollution. Waste water from industries includes sanitary waste and process water. These industrial pollutants degrade the ecosystem, damage aquatic ecosystem (Kumar and Pal, 2010). The rapid and unregulated growth of industrialization has led to an alarming deterioration in the quality of life and has given rise to a number of environmental problems. Pollution in the soil and water has a lot of adverse effects and thus is of great concern to the public health agricultural production and environment health. Vegetables are known to have positive effects on human health as they play a crucial role in preventing a number of chronic diseases (Agrawal *et al*., 2007). Treated Industrial and domestic waste water is being used for the irrigation of the agricultural land which contributes significantly towards the contamination of the soil in wastewater receiving area (Sinha *et al*., 2006). Heavy metals are hazardous contaminants in food, water and environment and they are non biodegradable having biological half lives (Heidarieh *et al*., 2013).

Tannery waste water plays a significant role in degrading the ground water quality as well as soil quality through leaching process. A significant part of the chemical used in the leather processing is not actually absorbed in the process, but is discharged into the environment (Gupta *et al*., 2007). Processing of leather require a large amount of fresh water along with various chemicals (Mondal *et al*., 2005). The tannery effluents contain chiefly chromium salts, copper, magnesium, iron, cadmium and arsenic salts when it discharged into the rivers it greatly affects the aquatic ecosystem. Various chemicals used in tanning include lime, sodium carbonate, bicarbonate, common salt, sodium sulphate, Chrome sulphate, fat liquors, vegetable oils and dyes. Industrial effluents from leather tanneries discharged untreated, if allowed to percolate into soil to ground water for a prolonged period seriously affect soil profile and the ground water table of the locality and make it unfit for drinking, irrigation and for general consumption. Heavy metal pollution of agricultural soils is one of the most severe ecological problems faced worldwide (Ajendran and

Mansiya, 2011). Therefore, long term irrigation using industrial /municipal waste water results in the build up of heavy metals in the soils which can restrict soil function, result in toxicity to plants, which contaminate the food chain by affecting food quality and safety (Ghosh *et al*., 2012). It has been established that a single tannery can cause pollution of ground water around a radius of 7 to 8 km (Bhaskaran, ...; CLRI, 1990). Presence of heavy metals in soil is known to have potential toxic impact on environmental quality and on human health via ground water and surface water (Mishra and Pandey, 2005; Akinola and Ekiyoyo, 2006). The distribution of heavy metals in the soil and their availability to plants are regulated by several factors including soil characteristics and the plant species, fertilization and irrigation characteristics. The composition and conditions of soil are important factors that affect Chromium mobility (Banks *et al*., 2006). The uptake and bioaccumulation of heavy metals in vegetables are influenced by many factors such as climate, atmosphere depositions and nature of soil. Increasing the concentration of heavy metals in soil increased the crop uptake. High accumulation of Pb, Cr and Cd in leafy vegetables due to atmospheric deposition has been reported by Voutsa *et al*. (1996; De Nicola *et al*., 2008). Tannery industry contains several organic and inorganic chemicals, which are toxic metals and they cause soil and water pollution. These effluents released on river or canal as well as dump into ground water and lead to contamination of chromium due to accumulation (Katiyar, 2011). Some paint producing industry also established their and after production effluent discharge in to open drain, directly into environment. In paint industry lead is used in different forms. Lead has been reported to be toxic to both man and aquatic life and has been recognized as pollutant to natural ecosystem even at low concentration (VanDyk *et al*., 2007; Dahunsi *et al*., 2012). The maximum concentration of these waste material absorbed by bioaccumulation process in cultivated crops irrigated by tannery effluent (UNIDO, 2005; Sahu *et al*., 2008). The level of heavy metals like Zn, Mn, Cu and Fe in vegetables collected and accumulation of greater concentration in edible portions of leafy or root than the storage organs of fruit (Jinadasa *et al*., 1997). Various researchers revealed heavy metals like Cu, Zn, Fe, Pb, Cd, Mn, Hg and Cr to be significant contaminants of vegetables in urban agriculture (Sharma *et al*., 2008; Yusuf *et al*., 2003). Most of industries discharge their effluent without proper treatment into nearby open pits or pass through unlined channels resulting in the contamination of ground water (Jinwal and Dixit, 2008). Singh *et al*. (2004) assessed the impact of waste water/ sludge disposal from sewage treatment plant (STP) in jajmau Kanpur (5 million L/ Day) and Dainapur Varansi (80 million L/Day) on health, agriculture and environmental quality in the receiving areas around Kanpur and Varanasi, Uttar Pradesh. So it becomes very important to monitor the vegetables quality as well as ground water quality and to measure the contamination and minimize the pollution. Due to Consumption of heavy metals through vegetables, they are found in human blood and urine of the population living in waste water irrigated area (Agrawal, 2009).

In India, The state of Uttar Pradesh alone responsible for over 50% of pollutants entering in the river due to partially treated effluent drained into river and also used for irrigation. In Uttar Pradesh, Kanpur is largest industrial and commercial centre. Kanpur is most polluted city because of large number of tannery industries is established. It is also known as Leather city. Pollution becomes acute when tanneries are concentrated in clusters in small area like Kanpur, India (Beg and Ali, 2008). The tannery industry Mushrooming in north India has covered the Ganga River into a dumping ground. Kanpur is one of major tannery cluster with production of about 1000 tons of raw materials per day. In Kanpur mainly Jajmau area is home to biggest leather tanneries, footwear, and manufacturer and leather goods. The industrial area of Jajmau Kanpur having 400 tanning industry. 99% of industries are performing chrome tanning process. In tanning process toxic effluent generated, which require precise care in treatment of effluent. The tannery wastewater is being contaminated with high levels of metals (Fe, Cr, Zn, Mn, and Cu), its use in irrigation contaminates the soil and vegetables/crops which when consumed caused serious health hazards to the consumer (Singha *et al*., 2006). There is CETP operating for treatment of tannery waste water. The treated tannery effluent is being used for irrigation nearby area, which is 1800 hectare, covered around 10 villages. The area is being irrigated with tannery effluent for last four decades which affected ground water table significantly. It has become grim due to improper function of CETP. Large number of tanneries and other industries are discharging their untreated and semi treated effluents into loamy drain, a storm natural drain at Unnao, Uttar Pradesh, India (Sahu *et al*., 2007). As per an estimate, about 80-90% of the tanneries use Chromium (Basic Chromium Sulphate) as a tanning agent. Chromium has many industrial uses and its unregulated application has led to the contamination of soil, sediments, surface and ground water (Barnhart, 1997; Kotas and Stasicka, 2000). Of this, the hides take up 50-70%, while the rest is discharged as effluent

(Bhatnagar *et al*., 2013). The treated effluent generated from common Effluent treatment Plants frequently used for Irrigation contaminating soil and ground water quality. Much waste water in urban areas discharges to ground (Ravenscroft, 2003).

Hence, the aim of the study is to analyze the ground water and water of influent, effluent of treatment plant in reference of physical and chemical properties and distribution pattern of heavy metals like Cr, Fe Mn, Zn in edible parts of vegetables grown in agricultural field of industrial area Jajmau, Kanpur where effluent water is being used for irrigation purposes. I have selected the villages of industrial area where treated industrial effluent deteriorating the all levels of soil profile and ground water quality due to leaching. The quality of ground water has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking water prescribed by Indian standard 10500-2012 given in Table no 1 and Waste water quality assessed by standard desirable limit as per Central Pollution Control Board (CPCB) are given in Table no 5 and for vegetable, the threshold limits of metals in edible parts of the plants have not been well documented. Recently, threshold limits of some of the metals in edible plant parts have been reported, which was considered safe for human consumption and as depicted in Table 2 (Sinha *et al*., 2006; Pollack and Favoino, 2004).

Scope and Objectives

The volume of untreated industrial effluent discharge is increasing day by day. Sewage and tannery treated, semi treated or untreated effluent discharge are polluting the soil and ground water through percolation and uptake by vegetables. In Jajmau area of Kanpur city one CETP and two STP are operational since 1995(36 mld UASB Tannery waste water Treatment Plant, 130mld ASP Sewage Treatment Plant, 5 mld UASB Sewage Treatment Plant). The ground water and soil quality has been contaminated possibly due to use of Effluent for irrigation. Use of untreated or partially treated sewage and industrial effluents in large quantities for irrigation, may have significant impact on subsurface water and on vegetables.

Objectives

Evaluation / assessment of ground water quality in Jajmau, Kanpur.

- Assessment of CETP Influent & effluent and impact on ground water in Jajmau, Kanpur.
- Distribution pattern of heavy metals on edible parts of vegetables.
- Statistical analysis of ground water and heavy metals on vegetable.

Materials and Methods

Study area

The district Kanpur lies between 80^0 21" East longitudes and 26^0 28" North latitude in Uttar Pradesh, India. It is situated on the left bank of Ganga River and the right bank of its tributary, Pandu River (Gowd Srinivas *et al*., 2010). Kanpur's small and medium scale industries are producing a large amount of untreated industrial waste which is in discriminately spread in the region. In Kanpur, Jajmau is a chronic polluted area and one of the biggest exporting centers of tanned leather. About 400 tanneries are located at Jajmau (Kanpur). The treated wastewater is being used more than two decades for the irrigation of crops and vegetables growing in an area of 1800 acre. Due to long term irrigation from contaminated wastewater, the area is selected for the present study and located at about 0.5 to 10 km distance from treatment plant.

Sampling sites

The sites identified for the sampling are extensively used for drinking purpose. Sampling was done in the year 2015 mainly in summer season. And the time of sample collection was between 9AM to 4 PM. For ground water, I have applied the grab sampling. A grab sample is anordinary sample, which is taken from a particular place representing the whole water quality. I have selected major villages of Jajmau industrial area and collected 10 samples from 10 identified locations namely as Sekhpur (S1), Jana(S2), Motipur(S3), Kishanpur(S4), Madarpur(S5), Movaiya(S6), Kulgao(S7), Trilopkpur (S8), Allolapur(S9), Rooma(S10) and 03 controlled site Left Chakeri(C1), Chakeri Station(C2) and Right Chakeri(C3) were selected where effluent was not using for irrigation purposes. For vegetable sampling, I was applied the random sampling in year 2015-2016 so I was selected 05 sites. Each site located between two site of Ground water First Site located between CETP effluent channel, Sekhpur(S1) and Jana (S2) namely as V1, Second site located between Kishanpur(S4) and Trilopkpur (S8) namely as V2, Third site located between Motipur(S3) and Allolapur(S9) namely as V3, fourth site located between Movaiya(S6) and Kulgao(S7) namely as V4 and fifth site located between Allolapur(S9) and Rooma(S10) namely as V5 and Influent and effluent sample (5 mld STP, 36 mld UASB based CETP, 130 mld ASP) was collected in same year from treatment plant. All sampling sites of ground water, influent & effluent water and

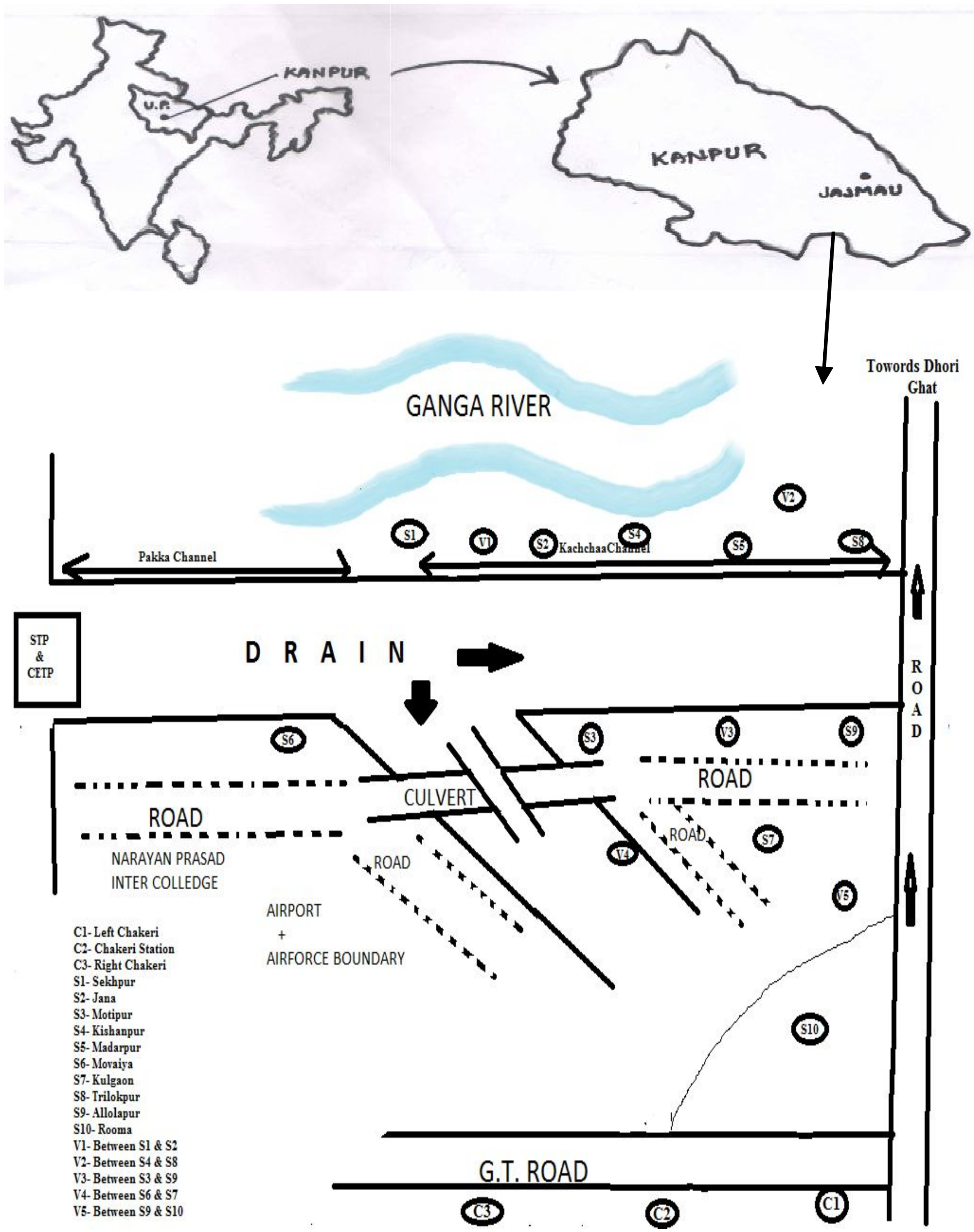

Fig. 1 : Showing different Sites of Ground water (Control C1-C3 and Industrial area S1-S10), Influent and Effluent of Treatment plant (STP and CETP) and Effluent Irrigated agricultural Field (V1-V5) at Jajmau, Kanpur.

vegetables have been illustrated in fig. 1.

Samples collection (Ground water, Waste water and Vegetable plant) and analysis

The ground water samples were collected from different hand pump ranging up to 120 feet along the effluent channel within the study area as well as control area near Jajmau industrial area. Waste water samples (treated and Untreated) from CETP and STP plants were collected which is being used for the irrigation of agricultural land. The method described by APHA 22nd

Table 1 : Showing the Standard Acceptable limit / Permissible Limits of drinking water.

Parameters	**Acceptable limit/ Permissible limit as per 10500-2012**
Temperature (^{0}C)	——
pH	6.5-8.5 / No Relaxation
Colour, Hazen Unit	5/15 Max
Dissolved Oxygen, mg/l	——
Alkalinity as $CaCO_3$, mg/l	200 /600 Max
Hardness As $CaCO_3$, mg/l	200 /600 Max
Calcium, mg/l	75 /200 Max
Magnesium, mg/l	30 /100 Max
Total Suspended solid, mg/l	——
Total Dissolved solid, mg/l	500 /2000 Max
Nitrate, mg/l	45.0 Max/ No Relaxation
Sulphate as SO_4, mg/l	200 /400 Max
Fluoride, mg/l	1.0 /1.5 Max
Chloride, mg/l	250 /1000 Max
Chromium, mg/l	0.05 Max./ No Relaxation
Arsenic, mg/l	0.01 /0.05 Max.
Lead, mg/l	0.01 Max/No relaxation

Table 2 : Showing the reported threshold limits of metals on vegetable.

Categories	**Zinc (mg/kg)**		**Chromium (mg/kg)**	
	Dry matter	**Fresh matter**	**Dry matter**	**Fresh matter**
Potato	14.0	—	0.40	0.675
Fruit	—	—	0.355	0.029
Vegetable (root, tuber, fruit)	41.0	—	0.698	0.065
Leafy vegetable	190.19	127.25	0.852	0.0607

Edn 2012 were followed during field and laboratory work. Ground water as well as wastewater Samples were taken in plastic cans and for dissolved Oxygen of ground water and BOD of wastewater water, 300 ml capacity BOD bottles by avoiding any kind of bubbles inside it. All the sampling cans and BOD bottles are previously rinsed with triple distilled water and also rinsed with ground water to be sampled. After collection of sample, some parameters like Temperature, pH, Electrical conductivity (RI) were determined immediately on sampling site by using pen type digital meter and Dissolved oxygen was immediately fixed by adding 2 ml Manganeous Sulphate and 2 ml of Alkaline Potassium iodide Azide solution at sampling point and for BOD, sampled were preserved in ice box for incubation and further analysis and other Samples were also kept in ice box and transported to laboratory for their physical, chemical and Heavy metals analysis. In ground water, Parameters were Colour, Dissolved Oxygen, Total Alkalinity (as $CaCO_3$), Total Hardness (as $CaCO_3$), Calcium (Ca), Magnesium (as Mg), Total Suspended Solids, Total Dissolved Solids, Nitrate (as NO_3), Sulphate (as SO_4), Fluoride (as F), Chloride (as Cl), Total Chromium (as Cr), Arsenic (as As) and Lead (as Pb), but in waste water, parameters were Chemical oxygen demand, Biochemical Oxygen Demand, Total Suspended Solids, Total Dissolved Solids, Sulphide and heavy metals like Total chromium, Iron, Zinc and Copper. All the samples were analyzed by referring Standards methods. Dissolved Oxygen analyzed by Winkler method, Total alkalinity, Total Hardness, Calcium, Magnesium and chloride analyzed by titrametric method, Total Suspended Solids and Total Dissolved Solids analyzed by gravimetric method as well as pen type meter, Nitrate, Sulphate, Fluoride were analyzed by Ultra violet Spectrophotometer (Make-Shimadzu, Model-UV 1800, Range-190-1100 nm), COD were analyzed by reflux method, for BOD, samples were kept in incubator for 3 days at 27^{0}C and heavy metal analysis done by ICP-MS make by Agilent. For the comparison of analyzed concentration of ground water and waste water sample with standard acceptable limits. Drinking water standard limits given by Indian Standard 10500-2012 and waste water sample limits were given by CPCB. The standard limits of ground water and effluent waste water is given in tables 1 & 5.

For vegetable plants, good quality samples of vegetables commonly grown at sampling site, Kanpur area throughout the year (2015-2016) in the seasons (summer and winter) from five different selected sites and brought to the laboratory. I was selected the test plant mainly Chilli, Black mustard, Coriander, Cucumber, Egg plant, Potato, and Sugarcane. These vegetable samples were collected randomly and used for the analysis. These vegetable were collected by hand, put it into polythene bags and brought to the laboratory for the further analysis. These vegetables were carefully washed with tap water to eliminate the soil and other contaminants. Special attention was given to edible parts, which were mainly for analysis. Then all the edible parts were separated and dried at room temperature to remove moisture, afterwards they were weighted and oven dried at 80 ^{0}C till to constant weight. Oven dried samples were powered. Take 1.0 gm. Grinded homogenously sample in 8 NXF100 rotor vessels. Add 4ml supra pure Nitric acid and 4ml Ultra pure water and keep the rotor vessels in the microwave oven. Set the temperature/power 240 ^{0}C with ramping 10 minute, pressure -900 Pa and hold time 30 minute or select a pre-defined method for vegetable. After sample digestion, transfer the sample in a 25ml volumetric flask and make up the volume with ultra pure water. Prepare a blank in same manner. All the samples were analyzed in three replicates. The heavy metal analysis was done by ICP-MS made by Agilent Model No-7700.

Results and Discussion

Physical and Chemical variables in water and waste water

The quality of water resources depends on the management of anthropogenic discharges as well as the natural physicochemical characteristics of catchment areas (Efe *et al*., 2005). The result of physicochemical and heavy metals of ground water (drinking water) samples of Control area C1 to C3 and industrial area S1 to S10 are given in tables 3 and 4 shows that the Pearson Correlation coefficient (r) matrix between physicochemical parameters of ground water, Jajmau, Kanpur. It measures the strength and direction of a linear relationship between two variables on a scatter plot. The value of *r* is always between +1 and –1. Influent and Effluent of 5 mld STP plant, 36 mld UASB tannery waste water plant, 130 mld ASP plant and Mixed Effluent are given in table 5 and heavy metals in vegetables collected and results have been deducted in table 6.

Temperature of ground water in study area was found between ranges 19.3- 23.93^{0}C in month of June 2015. The maximum temperature 24.3^{0}C was found on site S3. Temperature has negative correlation with DO, but positive correlation with EC and TDS. In waste water, temperature range found between 31-32^{0}C in influent samples and 32-33^{0}C in effluent samples in STP and CETP plants. Temperature is important for all the reaction of organism. The increase in temperature decreases the portability of water because of elevated temperature carbon dioxide and other volatile gases which impart taste are expelled (Karunakaran *et al*., 2009). pH of ground water was ranged between 7.4-8.12. The maximum pH was recorded on site C3 *i.e.* control area. It has been mentioned that the increasing pH appear to be associated with increasing use of alkaline detergents in residual areas and alkaline material from waste water in industrial areas (Chang, 2008). In CETP and STP plants, pH range was found between 8.3-8.5 in influent water and in effluent water between 7.8-8.1. Maximum pH was found in influent of tannery waste water. pH is considered as an important ecological factor and provides an important piece factor and piece of information in many types of geochemical equilibrium or solubility calculation (Shyamala *et al*., 2008). Colour used as true colour. In ground water, maximum colour was found on site S10 and minimum was found on site C1. Colour of water from which turbidity has been removed and the apparent colour of water includes not only due to substances in solution but also that due to suspended matter (NEERI). Electrical conductivity of water is a direct function of its total dissolved salts (Harilal *et al*., 2004). The average range of electrical conductivity from all thirteen sites was recorded 2327.9µs/cm. The maximum and minimum conductivity was found 4393.3µs/cm and 650µs/cm. Maximum and minimum EC were found on site S3 and C2. It is an index to represent the total concentration of soluble salts in water (Purandra *et al*., 2003). Conductivity is the capacity of water to carry an electric current. It is a good and rapid method to measure the total dissolved ions and directly related to total solids. It is a useful tool to assess the purity of water. Higher the value of dissolved solids, greater the amount of ions in water (Bhatt *et al*., 1999). Dissolved Oxygen is important to determine the quality of water. DO value of all thirteen sites ranges from 6.4 to 2.0 mg/l. Maximum DO is found on site C1 that is control area and minimum DO is found on Site S3 that is industrial area and the average value of all thirteen sites 3.96 mg/l. Aquatic organisms need dissolved oxygen to respire. DO concentration decreases in water during summer season due to deceased rate of oxygen diffusion from atmosphere to water. It is negatively correlated with temperature. In waste water Biochemical oxygen demand is found beyond the limits. Maximum BOD and COD were found in 260 mg/l and 786 mg/l in effluent of UASB tannery waste water plant. BOD range of influent water was 320-3590 mg/l and in effluent water was between 260-65 mg/l. COD and BOD are inversely correlated with Dissolved oxygen. Dissolved oxygen decreases with increasing of BOD and COD. In ground water, alkalinity ranges were found between 568.3-280.6 mg/l. It is total measure of the substances in water that have acid neutralizing ability. It is important for fish and aquatic life because it protects or buffers against pH changes. The alkalinity of water is due to the salts of carbonates, bicarbonates, borates and silicates along with the hydroxyl ions in the Free State (NEERI). The bicarbonate ion concentration is reflected mainly in alkalinity values in drinking water (Sarapata, 1994). Alkalinity is directly correlated with pH. Hardness is important factor to determine the quality of water. Total hardness of ground water in study area was ranged between 1412.66-282 mg/l. The maximum value of hardness was observed on S3 site and minimum was on C2 site. In ground water total hardness is mainly

Table 3 : Showing the mean values and range of measured physical and chemical variables of selected sites from Ground water Jajmau Kanpur.

	Temp (^{0}C)	pH	Colour (Hazen Unit)	EC (µs/cm)	DO (mg/l)	Alka-linity (mg/l)	Hard-ness (mg/L)	Ca (mg/L)	Mg (mg/L)	TSS (mg/L)	TDS (mg/L)	NO_3 (mg/L)	SO_4 (mg/l)	F (mg/l)	Cl (mg/l)	Cr (mg/l)	As (mg/l)	Pb (mg/l)
C1	21.3 (0.25)	8.12 (0.025)	4.67 (0.57)	933.33 (7.6)	6.03 (0.05)	332.3 (2.52)	294.66 (2.51)	63.3 (1.52)	31.66 (1.83)	9.66 (2.51)	667.66 (7.02)	5.36 (0.47)	10.56 (0.60)	0.63 (0.02)	36 (2)	0 (0)	0(0)	0(0)
C2	22 (0.2)	8.13 (0.04)	4.33 (0.58)	650 (5)	6.46 (0.11)	280.6 (3.05)	282 (2.64)	69.6 (1.52)	29.33 (1.35)	5 (2)	473.66 (3.21)	3.63 (0.25)	5.9 (0.4)	0.4 (0.01)	21.6 (2.51)	0(0)	0(0)	0(0)
C3	21.2 (0.17)	8.21 (0.02)	5 (0)	765 (10)	6.2 (0.1)	318 (2)	362 (2)	55.3 (3.21)	51 (0.89)	11.33 (2.08)	581.66 (10.40)	23.33 (1.15)	6.53 (0.30)	0.57 (0.01)	32.66 (2.08)	0(0)	0(0)	0(0)
S1	23.2 (0.15)	7.8 (0.015)	11.66 (2.88)	3177.66 (17.2)	3.6 (1.73)	522 (1.73)	1150.33 (5.50)	283 (11.35)	196.66 (6.78)	43 (3.6)	2587.66 (5.85)	70.33 (1.52)	299.33 (1.52)	2.23 (0.15)	832.66 (3.05)	0.07 (0.002)	0.001 (0.00095)	0.002 (0.001)
S2	23.2 (0.21)	7.4 (0.04)	6.66 (1.15)	2874.6 (177.6)	3.03 (0.05)	427 (2)	1131.33 (4.16)	262.3 (2.08)	152.33 (2.24)	45 (2)	2030.66 (15.04)	44.66 (2.51)	266.33 (2.30)	1.9 (0.1)	576.66 (3.51)	0.28 (0.37)	0.00023 (0.00012)	0.0003 (0.0001)
S3	24.3 (0.21)	7.33 (0.02)	21.66 (2.88)	4393.3 (534.1)	1.9 (0.1)	508.3 (2.88)	1412.66 (2.51)	353 (1)	241.66 (2.45)	54 (3.6)	2733.66 (168.96)	105.66 (2.08)	387 (2.64)	3.66 (0.20)	811.33 (1.52)	0.04 (0.0017)	0.005 (0.001)	0.0036 (0.0015)
S4	22.9 (0.15)	7.5 (0.02)	5.33 (0.57)	2796.33 (22.0)	3.03 (0.05)	423 (3)	1207 (1.73)	288 (3.46)	132.66 (1.96)	30 (5)	2515 (32.78)	89.66 (0.57)	365.66 (1.15)	2.8 (0.1)	748 (3)	0.03 (0.0015)	0.0023 (0.0015)	0.0004 (0.0001)
S5	23.2 (0.15)	7.44 (0.01)	11 (3.6)	2269.66 (13.8)	3.8 (0.1)	382.6 (2.51)	977.66 (2.51)	220.6 (3.78)	113 (1.78)	23.33 (2.51)	1816.66 (25.65)	57 (2)	184 (1)	1.1 (0.1)	536 (3.60)	0.02 (0.0015)	0.0036 (0.0011)	0.003 (0.002)
S6	20.1 (0.12)	7.55 (0.05)	6 (0)	2580.66 (14.0)	3.96 (0.15)	371 (3.60)	970 (2)	217.6 (2.51)	132.66 (2.24)	31.66 (1.15)	1972.66 (25.42)	52.33 (0.57)	272.33 (2.51)	0.67 (0.01)	603 (2)	0.02 (0.0021)	0.0013 (0.0006)	0.0023 (0.0011)
S7	19.3 (0.3)	7.61 (0.04)	5 (0)	2922.33 (17.8)	3.16 (0.05)	390 (2)	1176.33 (4.04)	271 (1)	145.66 (0.49)	32.66 (3.78)	1831.66 (25.16)	57.33 (1.52)	191.33 (1.52)	0.61 (0.02)	417 (2)	0.021 (0.001)	0.003 (0.001)	0.0002 (0.0001)
S8	20 (0.2)	7.7 (0.02)	4.66 (0.57)	1873 (18.1)	4.3 (0.1)	568.3 (170.33)	771 (1)	180.3 (2.08)	142.66 (2.24)	32 (2.64)	1347 (10.81)	72.33 (2.51)	102.66 (2.08)	0.74 (0.03)	263.66 (2.30)	0.021 (0.0026)	0.0003 (0.0001)	0.0023 (0.0015)
S9	21.2 (0.2)	7.72 (0.02)	11.66 (2.8)	1956.66 (16.1)	3.5 (0.1)	362 (1.73)	665 (3)	195 (3)	85 (2.68)	42.33 (2.51)	1345.66 (6.02)	53.66 (2.51)	138.33 (3.05)	0.91 (0.02)	394.33 (2.08)	0.14 (0.01)	0.0004 (0.0002)	0.002 (0.001)
S10	23.9 (0.21)	7.61 (0.03)	28.33 (2.8)	3070 (17.3)	2.53 (0.05)	476 (1.73)	1053.66 (3.21)	244.3 (4.04)	209.33 (3.60)	66.33 (5.68)	2266.33 (30.66)	67.66 (1.52)	394.66 (2.51)	3.13 (0.15)	561.33 (1.52)	0.36 (0.01)	0.0046 (0.0015)	0.0056 (0.0015)
Mean	21.98	7.70	9.69	2327.9	3.96	412.4	881.05	207.9	128	30.79	1705.38	54.07	201.9	1.49	448.79	0.077	0.0017	0.0017
Min.	19.3	7.4	4.33	650	1.9	280.6	282	55.3	29.33	5	473.66	3.63	5.9	0.4	21.6	0	0	0
Max	24.3	8.21	28.33	4393.33	6.46	568.3	1412.66	353	241.66	66.33	2733.66	105.66	394.66	3.66	832.66	0.36	0.005	0.0056

Table 4 : Showing the Pearson correlation matrix between physicochemical parameters of Ground water, Jajmau, Kanpur.

	Temp	pH	Colour	EC	DO	Alkalinity	HRD	Ca	Mg	TSS	TDS	NO_3	SO_4	F	Cl	Cr	As	Pb
Temp	1																	
pH	-0.380	1																
Colour	.658*	-0.376	1															
EC	0.469	-.862**	.558*	1														
DO	-0.463	.865**	-.590*	-.971**	1													
Alkalinity	0.476	-.625*	.563*	.833**	-.826**	1												
HRD	0.415	-.889**	0.431	.975**	-.949**	.792**	1											
Ca	0.442	-.880**	0.440	.977**	-.970**	.808**	.985**	1										
Mg	0.505	-.745**	.660*	.947**	-.916**	.937**	.904**	.900**	1									
TSS	0.478	-.691**	.787**	.847**	-.904**	.792**	.775**	.792**	.876**	1								
TDS	0.531	-.829**	0.516	.970**	-.949**	.841**	.967**	.971**	.921**	.804**	1							
NO3	0.395	-.790**	0.461	.852**	-.868**	.845**	.868**	.885**	.853**	.717**	.881**	1						
SO_4	.596*	-.795**	.650*	.927**	-.917**	.772**	.908**	.899**	.886**	.859**	.960**	.818**	1					
F	.843**	-.589*	.738**	.768**	-.763**	.754**	.721**	.736**	.787**	.749**	.812**	.729**	.864**	1				
Cl	.538	-.815**	0.441	.929**	-.917**	.787**	.929**	.948**	.861**	.753**	.980**	.841**	.929**	.761**	1			
Cr	0.426	-0.244	.852**	0.358	-0.483	0.393	0.255	0.273	0.448	.771**	0.338	0.273	0.509	0.507	0.298	1		
As	0.443	-.590*	.721**	.713**	-.685**	0.520	.681*	.658*	.700**	.619*	.654*	.637*	.677*	.644*	0.545	0.421	1	
Pb	.585*	-0.526	.816**	.578*	-.637*	.565*	0.474	0.532	.630*	.673*	.555*	.605*	.579*	.598*	0.549	.642*	.693**	1

*- Correlation is significant at the 0.05 level (2-tailed). **- Correlation is significant at the 0.01 level (2-tailed).

contributed by calcium, magnesium, carbonate, bicarbonate, Sulphate and chloride of calcium and magnesium salt (Ramesh and Thirumangai, 2014). Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of water (Trivedy and Goel, 1986). In present study, most of the samples have high hardness and crossed the permissible limits according to standard IS: 10500-2012 and this may be due to industrial effluents discharges and leaches. Increasing hardness in drinking water has adverse health effect. Calcium is the cation found in ground water. It was found from ranges between 353-55.3 mg/l. The permissible limits of drinking water are 75 mg/l so all the samples in industrial area exceeded the permissible limits except control area C1, C2, C3 sites. Rapid industrialization in the area contributes to high concentration of calcium in ground water. Calcium and magnesium are most common constituents of natural waters and important contributors to the hardness of water. In ground water the calcium content generally exceeds the magnesium content. Magnesium was found between 241.66-29.33 mg/l. Most of the sampling site exceeded the permissible limits. Magnesium occurs in lesser concentration than calcium due to the fact that the dissolution of magnesium rich minerals in slow process then calcium. The term solids refer to matter either filterable or in filterable that remains as residue upon evaporation and subsequent drying at a defined temperature. Maximum TSS was found on site S10 that is 66.33 mg/l and minimum was found on site on site C2 that is 5 mg/l. In present study, TDS was ranged from 2733-473.66 mg/l and maximum was found on site S3 and minimum was found on site C2. In effluent waste water, maximum TSS was found in UASB tannery waste water i.e. 275 mg/l. TDS value indicated the general value of water quality is usually related to conductivity. The level of TDS is one of the characteristics, which decides the quality of drinking water. As per Indian standard 10500-2012, more than 500 mg/l of TDS is not desirable for drinking purposes but more highly mineralized water may be used where better quality water is not available (Jain, 2002).

In waste water, TDS range of influent water was 1250-10860 mg/l and in effluent water TDS

Table 5 : Showing the physicochemical parameters of Influent and Effluent of Treatment Plant with Permissible Limits.

Parameters	5 mld domestic Waste Water Treatment plant Jajmau, Kanpur		36 mld UASB tannery waste water treatment plant (C.E.T.P.) Jajmau, Kanpur		130 mld ASP Domestic Waste Water Treatment plant Jajmau, Kanpur		Treated Effluent of Irrigation Channel	Influent		Effluent		Permissible limits as per CPCB Guidelines	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Mixed Effluent	Max	Min	Max	Min	Land for Irrigation	For Public Sewer
Temp. ^{0}C	32	33	31	32	32	32	32	32	31	33	32	—	—
pH	8.3	8.1	8.5	7.9	8.4	7.8	7.9	8.5	8.3	8.1	7.8	5.5-9.0	5.5-9.0
COD, mg/l	975	189	10760	786	1086	196	386	10760	975	786	189	—	—
BOD, mg/l	320	65	3590	260	355	65	128	3590	320	260	65	100 Max	350 Max
TSS, mg/l	860	95	7925	275	950	75	135	7925	860	260	65	200 Max	600 Max
TDS, mg/l	1385	1280	10860	3560	1250	980	1860	10860	1250	3560	980	—	—
Sulphide (S^{-}), mg/l	37	58	114	178	46	Nil	53	114	37	178	Nil	—	—
Total Chromium(Cr), mg/l	7.5	3.5	114.6	8.7	11.5	1.7	4.8	114.6	11.5	8.7	1.7	—	2.0 Max
Iron(Fe), mg/l	5.1	4.7	4.6	4.3	4.9	4.7	4.0	5.1	4.6	4.7	4.0	—	3.0 Max
Zinc(Zn), mg/l	0.51	0.45	0.81	0.79	0.68	0.61	0.51	0.81	0.51	0.45	0.79		5.0 Max
Cuppor (Cu), mg/l	0.21	0.18	0.15	0.13	0.23	0.19	0.10	0.23	0.15	0.19	0.10	—	3.0 Max

range was 980-3560 mg/l. Nitrate is the most highly oxidized from of nitrogen compounds commonly present in natural waters. In ground water, maximum nitrate was found on S3 site that is 105.66 mg/l and minimum was found on C2 site that is 3.63 mg/l. The Average value of nitrate on all sites was 54.07 mg/l. Nitrate is form due to chemical fertilizers, decayed vegetable and animal matter, atmospheric, domestic effluents and sewage sludge disposal to land. Excessive concentration of nitrate in drinking water is considered hazardous for health. Sulphate ion usually occurs in natural waters. The compound of sulphate is soluble in water. In ground water, Sulphate ranged from 394.66-5.9 mg/l. Maximum concentration of sulphate found on site S3 site. In waste water treatment plant, sulphate converted into sulphide during treatment of water due to this sulphide increases after treatment of waste water in all treatment plant except ASP domestic waste water plant. In drinking water Fluoride is also important. Excessive concentration of fluoride causes several diseases. Fluoride ions have dual significance in water supplies. High concentration of fluoride causes florosis. Fluoride was found within the permissible limits except few sampling sites. Fluoride is found maximum on S3 Site. As per Indian standard 10500-2012, more than 1.0 mg/l of Fluoride is not desirable for drinking purposes so it is essential to mention the F- concentration between 0.8 to 1.0 mg/l in drinking water. Salt is Essential component of drinking water. Maximum concentration of Chloride was recorded as 832.66 mg/l on S1 site. High concentration of chloride is due to the invasion of domestic wastes and disposals by human activities (Jha and Verma, 2000). Chloride usually occurs as Nacl, CaCl2 and $MgCl_2$ in widely varying concentration in all natural water. They enter in water by solvent action on salts present in the soil, from polluting materials like sewage and trade waste (Sheikh and Mandre, 2009).

Pollutants include toxic levels of metal contaminants such as chromium, Mercury, Arsenic and Lead. Heavy metals are either essential nutrients or relatively harmless but can be toxic in larger amounts or certain forms. The Cr is highly toxic to human even in low concentration. The maximum concentration of Chromium in ground water in study area was 0.36 mg/l on S10 site and 0.13 mg/l on S1 site. As per IS 10500-2012, the permissible limit of Cr in ground water is 0.05 mg/l. Chromium is found on two forms, hexavalent chromium and trivalent chromium. Hexavalent chromium is the most toxic

Table 6 : Showing the concentration of metal variables (mean values) in edible part of vegetables (plants) from selected site of Jajmau, Kanpur.
(Average of site average and average of standard deviation of all sites)

	Concentration of Metals (µg/g)			
	Chromium	**Iron**	**Zinc**	**Manganese**
Black Mustard (V1-V5)	10.42(0.187)	841.2(12.478)	190.67(12.62)	55(2.195)
Chilli (V1-V5)	4.34 (0.168)	261.66(7.554)	70.96(3.583)	2.34(0.15)
Potato(V1-V5)	8.19(0.129)	498.2 (2.644)	115.01 (0.27)	7.58 (0.185)
Cucumber (V1-V5)	16.44 (0.345)	314.07 (6.174)	80.05 (1.312)	25.07 (1.61)
Egg Plant (V1-V5)	0.19(0.044)	87.07(2.092)	50.4 (0.921)	22.62 (0.758)
Sugarcane (V1-V5)	18.46 (1.151)	644.46 (1.381)	82.06 (0.883)	20.48 (0.197)
Mean	9.67	411.11	98.19	22.18
Max	18.46	841.2	190.67	55
Min	0.19	87.07	50.4	2.34

form of chromium. Chromium is the most worrisome of these: popular in the tanning industry because it makes leather goods (Article on Ground Water Pollution, 2011). The chromium is toxic and even in all small concentrations cause disease in humans and animals. Tannery effluents are mostly characterized by high organic loading, salinity, chromium. In waste water, maximum concentration of Chromium in influent water was 114.6 mg/l and in effluent water maximum concentration was 8.7 mg/l in tannery waste water treatment plant. Other Metals like Lead and Arsenic were found from below detection limits on all sampling location of ground water. Lead contamination of ground water that could be associated with industrial activities, has been reported in many parts of the world [63-64]. In waste water, other metals like Iron, Zinc and copper were found but not in excessive amount. In effluent water, Iron was found between 4.0-4.7 mg/l, Zinc found between 0.45-0.79 mg/l and Copper found between 0.10-0.19 mg/1.

Accumulation of metals in vegetable plant

The vegetable plants were collected from different sites of Jajmau, Kanpur. The result of different vegetable plant samples analyzed for Chromium, iron; zinc and manganese are shown in table 6. Locations of vegetable sites in effluent irrigated agricultural field are given in fig. 1. In vegetables, total metal concentration was estimated in all the sampling locations collected from different sites (V1-V5). Tannery waste water is being contaminated with high levels of metals (Fe, Cr, Zn, Mn, Cu), its use in irrigation contaminates the soil and vegetables/crops, which when consumed caused serious health hazards to the consumer. Accumulation of heavy metals and their uptake by different plants parts depend on the concentrations of available heavy metals in the soil and form of metals (Agrawal *et al*., 2007). Mondal *et al*. (2007) have reported that the accumulation of metal from soil to plant parts did not follow any particular pattern and varied with respect to metal, species and plant parts. The accumulation of metals in the vegetable plants showed heterogeneous trend. The results are discussed on basis of toxic metal mainly Chromium. In black mustard, maximum chromium was 11.54µg/g and minimum was 9.12 µg/g and the mean value of all site was 10.42 µg/g, in Chilli plant, Range of Chromium was between 2.21-9.12 µg/g with mean value 4.34 µg/g, In Potato, The mean value of all sites was 8.19 µg/g and range was found between 6.5-10.9 µg/g, In Cucumber, the range of Cr found between 12.69- 21.22 µg/g and mean value 16.44 µg/g, In Egg Plant, Cr range was between 0-0.79 µg/g, In Sugar cane maximum Cr was 26.2 µg/g and the with mean value of all sites was 18.46 µg/g. In all plants maximum concentration was found on mainly site V1 except in Egg plant, minimum Cr was found on site V2. This is near to outlet of effluent channel. Chromium was accumulated in higher concentration in edible part of plant. Concentration of iron in edible part of black mustard in all sites ranged between 745-912µg/g (841.2), in Chilli 200-345µg/g (261.66), in potato 375-615µg/g (498.2), in cucumber 223-435µg/g (314.07), in egg plant 64-113µg/g (87.07), in sugarcane 575-725µg/g (644.46). In all sites maximum concentration found on V1 site. Accumulation of iron is also found higher concentration.

Like chromium and Iron, not much difference recorded in accumulation of Zinc. It was observed that maximum concentration was 260 µg/g found in Black mustard on site V1 and minimum was 45 µg/g found in Chili plant on site V4. Maximum mean value was 190.67µg/g in black mustard. Among all the metals studied, least concentration of manganese found in comparison to other metals. The mean value of manganese in all vegetable plants like black mustard were 55 µg/g, in chili 2.34 µg/g, in cucumber 7.58 µg/g, 25.07 µg/g, in egg plant 22.62 and in sugarcane 20.48 µg/g. The maximum concentration of manganese was 63.33µg/g found in black mustard on site V2 and minimum was 1.69µg/g on site V4. Over all analysis of metals in edible part of vegetable plant was found high and some researchers said that heavy metals concentration was found high in leafy vegetables than non leafy vegetable/crops (Sinha *et al*., 2006). Heavy metals are easily accumulated in the edible parts of leafy vegetables as compared to grain or fruit crop (Mapanda *et al*., 2005; Tasrina *et al*., 2015).

Conclusion

The present study reveals the groundwater quality and heavy metals concentration on vegetable of industrial area Jajmau, Kanpur (India) was studied and the following conclusions were arrived. Ground water samples of controlled area is suitable for drinking purposes because all content is in balance form But in industrial study area is of brackish water type with high colour value based on the concentration of TDS. The effect of treated effluent with high TDS affecting the ground water quality in surrounding villages. The villages, which are near to effluent channel, ground water is highly polluted as well as heavy metals accumulation is high on vegetables. Mainly S1, S2, S3 and V1, V2 are located near effluent channel. On vegetables, heavy metals mainly Cr and Fe are in high concentration. In industrial area ground water is not desirable for drinking purpose due to high TDS. A major portion of groundwater of this area is hard water due to higher Calcium, Magnesium and Chloride content. Chromium is also present in concentrations above the permissible limits of the groundwater samples. The chemical composition of groundwater is similar to that of the treated effluent and Metal absorption in normal vegetation is high due to treated effluent is being used for irrigation purposes. The groundwater and in this area has been concentrated with the chemicals that are used during the tanning process so ground water of industrial area is only suitable for irrigation purposes and soil is not much suitable for agricultural purposes. Overall, it is important to carry out removal of salinity along with chromium from the effluent during the treatment process. New technologies should be developed to prevent the infiltration of leachate to reduce the pollution. Artificial recharge and rainwater harvesting can be implemented to improve the present groundwater quality in this area.

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