INTRODUCTION

1.1 Background

Pollution is an undesirable change in the physical, chemical or biological characteristics of environmental components which may cause harmful consequences that become responsible for deteriorating life of living things and its environment (Odum, 1971). Human activities have been one of the major causes of introducing various kinds of pollution in the environment in the last few decades. With the expansion of human population in the world, numbers of industries have also been increasing day by day. There is no doubt that industries have been one of the major sources of environmental pollution. They are the major contributors for the air and water pollution (Kannan, 1991). In most of the developing countries problem of environmental pollution is appearing as a serious problem due to the limited economic and technical resources (Rana and Jomeson, 1995).

Industries generate waste materials and useless by products to certain extent and magnitude during the processing and manufacturing of intermediate chemical and end products (Kannan, 1991). Such useless products and waste in liquid form is called effluent which cause pollution if released in the environment without proper treatment. Various levels of organic and inorganic pollutants are found in industrial waste and effluent. Such as acids, alkali, inorganic ions, phenols, heavy metals etc. (Sharma, 1993). The word 'effluent' also refers to the impure water containing inorganic salts, organic compounds, microbial contamination and turbidity disturbing the natural hydrologic cycle. The effluents of various industries are generally rich in essential plant nutrients and organic matter but sometimes have high concentrations of heavy metals like Zn, Cu, and Pb. The disposal of wastes from industrial source is becoming a serious problem throughout the world (Santiago *et al*., 2004).

Among several types of industries, brewery and distillery industries play major role in polluting the environment. The organic effluent (spent wash) discharged by such industries is one of the most complex, troublesome and strongest organic, industrial effluent having extremely high BOD and COD values (Nagraj *et al*., 2006).

Industrialization in the context of Nepal is very slow. Even after more than ten decades of industrial development, Nepal is still in the early stage of industrialization. In 1994, the total industries in Nepal were registered as 4,487 (Anonymous, 2001). Between 2002/2003 and 2005/2006, a total of 442 new industries have been registered in Nepal (CBS, 2006). At present, more than 5,000 industries have been registered in Nepal. Out of them 56 distillery industries have been established in Nepal (Dhital *et al*., 2001). Besides these the number of cottage and small industries registered in Nepal in the first eight months in 2005-2006 is 4,556 (CBS, 2006).

There is a common practice in Nepal to discharge untreated or partially treated industrial effluent directly or indirectly into a nearby river or to the agriculture field. Because of such practice streams and river water which are used for various purposes besides irrigation have been polluted. Out of 4,000 industries in Nepal 175 industries were identified to be the significant source of pollution (Anonymous, 1991). Many industries in Nepal discharge their effluent strength enough than industrial effluent standards set by the Ministry of Population and Environment (MOPE) directly or indirectly into land or small channel loading to the nearby river. Out of total industries in Nepal, 22 different industries were found almost violating the effluents standard and polluting nearby river, agricultural land and soil (Sah, 2003). Water quality of most of the rivers and streams has been degraded. Such water is no more safe for human being, livestock and irrigation. Numbers of studies have found the presence of chemical and bacteriological content of the industrial effluent in Kathmandu valley (Sharma and Rijal, 1998; Miyoshi, 1987; Anonymous, 1987a). However due to the absence of better alternatives many farmers in urban areas of Kathmandu valley are compelled to use polluted river water or direct industrial effluent to irrigate their cropland (Ghimire, 1994).

Regarding the impact of industrial effluent on land and crop, a number of studies have been done in different countries with different plants (Thakural and Kaur, 1987, Fageria *et al*., 1989, Ghimire, 1994). The environmental impact of reuse of industrial effluent is not well documented particularly in developing countries where the irrigation requirements are large (Mukharjee *et al.*, 2006).

In several reports on industrial effluent it has been stated that the concentration of many toxic substances that are discarded by industries are well within the acceptable limits. However, the unorganised and unplanned establishment of industries may create serious problem in the future (Chaudhary, 1983; Ghimire, 1994; Thapa, 1994). Municipal waste water and effluent from certain industries such as paper, milk, breweries, distilleries, sugar mill, dairies, etc. are widely used to irrigate agricultural fields (Hoddy, 1991; Sammy *et al.*, 1995). All the toxicants present in the industrial effluents may create serious long term toxicity effect to the living organism when they come in contact to the living organism. However, the degree of toxicity depends upon their concentration and length of exposure to the susceptible site (Kannan, 1991).

Industrial effluents are a major source of soil pollution. These effluents are disposed directly on open land or in rivers and ultimately find their way to the soil through irrigation. The growth and distribution of plants are highly influenced by soil factors. The most important sources of water for plant are soil water. Hence, the soil texture will be obviously altered if the soil is irrigated by industrial effluent carrying toxic substances (Jha *et al.*, 1995). Thus, the effluent should be fairly treated before their use in irrigation (Hoddy, 1991; Sammy *et al.*, 1995). Industrial effluents rich in heavy metals may cause enrichment of heavy metals in the top soil if it is regularly applied to soil in excessive amount and ultimately may reduce yield and impure the quality of crops (Singh *et al.*, 1985). Irrigation with treated or untreated industrial effluent is relatively new practice and it is seen as a low cost option for wastewater disposal and as an important economic resource for agriculture due to its nutrients value (Mukharjee *et al.*, 2006). However, usually use of such untreated effluent for a long time causes adverse impact on soil fertility and crop plants.

1.2 Environmental Justice

A clean, healthy and safe environment is fundamental right of all human beings. Environmental justice has emerged recently as a new concept to address this fundamental right. The concept of environmental justice for the first time was brought up in USA. The first National People of Colour Environmental Leadership Summit held on October 24-27, 1991 in Washington D.C. drafted and adopted 17 principles of Environmental Justice. (Appendix VIII). The principle number 2 demands that public policy be based on mutual respect and justice for all people from any form of discrimination or bias. The main goal of it is to ensure the justice over the injustice regarding environmental issues. According to U.S. EPA (2000), environmental justice is the fair treatment to people of all races, culture and income levels with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Fair treatment implies that no group of people including as racial, ethnic or a socio-economic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial municipal as commercial operations on the execution of federal, state, local and tribal programmes and policies.

Similarly, Environmental Justice principle number 6 demands the cessation of all production of all toxins, hazardous wastes and radioactive materials and that all parts and current producers be held strictly accountable to the people for detoxification and the containment at the point of production. On the basis of these two principles it can be understood that principles of environmental justice focus on the right of all people to live in healthy and clean environment.

1.3 Environmental Justice in Nepal

Environmental problems are getting serious attention in recent years in academic field as well as by political and government agencies, media and grassroots levels (Chaudhary and Jha, 2003; Ghimire, 2003). The concept of environmental justice is relatively new to Nepal and not so many studies and researches have been conducted related to it. Though the concept is new, there are plenty of issues regarding environment that clearly depict the necessity of environmental justice.

The increasing pollution of air, water, soil and noise, increased solid waste in city areas, land fill sites and associated conflicts, loss of forest and biodiversity, problem in natural resource management, establishment of industries without waste treatment plants are the major issues which demand the role of environmental justice in Nepal. More than half population in rural areas are suffering from basic health care facilities, necessary education, minimum quantity of food and clean drinking water. Similarly urban people are suffering from pollution caused by haphazardly growing urbanization.

In Nepal most of the industries have been established without or with low quality waste/effluent treatment plants. Such industries have brought adverse impact on the local environment of the industrial area or city. Mostly the farmers and low income resource people get affected by such industries and factories. Beside these, there is not so definite rules and regulation of compensation system. Hence poor people always have to bear great loss.

These all problems regarding environment clearly reveals the relevance of implementation of principles of environmental justice in Nepal. It can't be denied that several decisions made by Nepal government in past years are in favour of environmental justice. But those decisions are weak at implementation level and are only limited up to paper work (Belbase, 2006).

1.4 Statement of Problem

Nepalgunj municipality is one of the growing industrial towns of Nepal. Many industries have been established in Nepalgunj municipality and the VDCs near to it. Being located near to Indian boarder, industrial development in the area is occurring smoothly. Most of the industries and factories have been established without EIA study. These industries are located either nearby human settlement or nearby agricultural crop fields and river/ponds or canals. Almost all these industries lack effluent treatment plant and hence discharge the untreated effluent to surrounding open environment directly or indirectly to nearby river or canals. Such practices discharging untreated effluent has caused negative effects on the local people and local environment of the area, especially farmers of the areas are being affected more.

The exact study points of the present research are the two of the VDCs of Banke district which have been influenced by the establishment of the distillery industry. The main occupation of people of the areas is farming. Mostly the low-income people or farmers who totally depend on farming for the livelihood are being affected. The distillery factory has been frequently discharging its effluent (spent wash) near by a river called Kiran khola. Local farmers have no idea of the negative or positive effect caused by the effluent mixed water in their crop plants and soil of their fields. Especially the farmers with poor economic status are bound to use the polluted water for irrigating their crop-fields.

The farmers of that area have no idea of environmental justice and do not know about the right way and legal access to fight against this injustice. Hence, they are bound to bear the loss caused by the distillery factory. Sometime the cattle of the farmers die or have miscarriage due to consumption of the effluent mixed river water. Besides these local people are highly influenced by the offensive odour of the spent wash which has polluted the fresh air of the local area.

1.5 Justification

In Nepal concerns over industrial effluent pollution on land and their effect on germination have been raised recently and very few studies have been done in this regard (Chaudhary, 1983, HMG 1990; Ghimire, 1994; Thapa, 1994; Jha and Niroula, 1998; Khadka, 1998; Shah *et al.*, 2000). Whatever studies had been done till now have revealed a necessity for detailed study regarding the magnitude of impact of industrial wastewater including effluent on agricultural crops. The understanding of crop responses to such industrial effluent may have a practical significance in agricultural production (Ghimire and Bajracharya, 1996). Such understanding may be related to physicochemical characteristics of the soil irrigated by the effluents and selection of right crop species to grow in effluent irrigated soil. The knowledge of the chemical composition of industrial wastes is of great importance in deciding the method and the extent of its application to the agricultural land (Sah *et al.*, 2000). Study of industrial effluent may also be helpful to find the non toxic level of dilution percentage of the effluents and also can identify the method to treat the effluent.

No such research work on the industrial effluent pollution and its effect on agricultural crops and environmental justice have been conducted in Banke district, especially in the study area Khajura and Bageshwori VDCs which are the main areas for agricultural crop production of the district. Besides this, the area is inhabited mostly by farmers of low income resource. This study will be helpful to assess the effect of distillery industrial effluent on some important agricultural crops and also record the status of environmental justice in relation to socio-economic and equity in the study area.

1.6 Objectives

i. To analyze the physicochemical characteristics of the effluent discharged by the distillery and identify its toxicity level for crop plants.
ii. To measure the effect of the effluent on germination and growth of crop plants.

iii. To assess the impact of the effluent in the quality and productivity of soil.

iv. To evaluate the status of environmental pollution caused by the distillery industry effluent and identify environmental injustice to local people due to the industry.

1.7 Limitation of the Study

This study is based on the field and lab work. Lab work included determination of the physicochemical parameters of the effluent and soil, where as fieldwork comprised the collection of primary and secondary data with the help of standard questionnaire during the regular field visits.

Due to limitation of sophisticated lab facilities, few physicochemical parameters of the effluent are missing to be determined. Similarly, due to unfavourable political situation of the country this dissertation may not present the complete documentation to reveal the injustice faced by the local farmers of the areas.

2. LITERATURE REVIEW

Water pollution by untreated industrial waste water has been one of the major issues of environmental pollution in Nepal. Several studies regarding industrial pollution have been conducted by several scholars, institutions and organization in Nepal and abroad.

2.1 Industrial Effluent Pollution

Shrestha (1980) studied the chemical nature of Bagmati river and found that high fish mortality every year in Bagmati river over the months of July and August was due to low level of dissolved oxygen approximately 2 to 3.5 mg/l.

Upadhyaya and Roy (1982) studied chemical parameters of Dhobikhola, Manohara, Nakkhu Khola, Balkhu Khola, Bishnumati and Bagamati throughout a year and found higher total dissolved solids, specific conductance values and concentration of Mg, K and Cl in the Bagmati and Bishnumati rivers. Similarly, Khadka (1983) examined major ions in the Bagmati river near the Pashupatinath temple and found that the concentration of Na+ and Cl was higher in sample collected down stream of the temple than upstream.

Sharma (1986) examined the effect of Bansbari Tannery, Jawalakhel Distillery, Balaju Industrial District, Carpet factories and Patan Industrial District and found that Bansbari effluent and carpet effluent had higher BOD, COD, NH_3-N than Balaju Industrial District and distillery effluent. The tannery effluent had very high concentration of chromium.

Anonymous (1987b) studied the impact of the Bhrikuti and the Everest Paper Mills in the Narayani and Orahi rivers. It was found that the river was highly polluted at the initial area of mixing of effluents. BOD of Bhrikuti paper mill and Everest paper mill was found to be 918 and 180 mg/l respectively.

Miyoshi (1987) measured the levels of different parameters in Bansbari tannery effluent, Dhobi-Khola and in domestic sewage at Bouddha, Balaju and Kalimati. He found that concentration of pollutants were very high in tannery effluent. DO level was less than 1mg/l. The BOD and COD values were highest for Kalimati sewage at 582mg/l and 250mg/l respectively.

Anonymous (1987) investigated the river water pollution caused by effluent discharged by Nepal leather and tanning industries in Birgunj, Nepal Leather Industry in Bhairahawa and the Bansbari Tannery in Kathmandu. The report showed that the wastewater did not meet the environment quality standard proposed for Nepal for in land waters.

Sharma and Rijal (1988) studied the microbial and chemical pollution of the river like Bagmati, Bishnumati and Dhobi Khola. The effluent from Bansbari Tannery, Balaju Industrial District, Carpet factories and Jawalakhel Distillery were tested. Effluent from tannery and carpet factories had the lowest DO levels and was anaerobic during the summer season. Nitrite concentration was highest in distillery effluent while COD was highest in the effluent from tannery and carpet factories.

Napit (1988) investigated pollution of the Bagmati in Pashupati area. He found that physical characteristics such as colour, turbidity and suspended particles exceeded desirable levels. However, the chemical parameters tested didn't exceed the WHO standard.

Anonymous (1989) analysed the industrial effluent in Pokhara and Biratnagar and found high level of organic pollutants. The BOD and COD values of Pokhara industrial district effluent were 610 mg/l and 880 mg/l respectively where as for Raghupati Jute Mill of Biratnagar, BOD and COD were found to be 988 mg/l and 1480 mg/l respetively and 28 mg/l and 43 mg/l respectively for Golchha Iron Indsutrial effluent. Effluent of Raghupati Jute Mill and Golchha Iron Industry were found to be highly acidic with pH values 2.7 and 3.3, respectively.

Anonymous (1989) studied the chemical and microbial components of Bansbari shoe effluent, Balaju industrial district and carpet factory effluent along with sewerages at Bauddha, Balaju and Kalimati. The DO value of carpet factory effluent was nill while other samples also had very low DO content.

Other parameters such as BOD, COD and HN_3-N were found above WHO guidelines value.

Shrestha (1990) summarized that the Bagmati river and its tributaries maintain good chemical and biological quality until they reach the urban area. The pollution of the aquatic ecosystem occurs after the river water enter the city area due to mixing of untreated municipal and industrial waste water of Kathmandu and Patan.

Anonymous (1992) examined the pollution of BID and rated down direct discharge of untreated waste water through a common sewage system. The pH and COD values were higher than Nepalese standard. Higher concentration of alkaline organic wastes was also observed.

Sharma (1993) studied the impact of domestic and industrial wastes on river pollution and observed the chemical and bacteriological characteristics of domestic sewage (Bouddha, Balaju and Kalimati) and industrial effluent (BID, Bansbari shoe factory and CF) and reported the BOD, conducticity, COD, chromium, etc. were higher than WHO tolerance level and DO was almost zero.

Gewali *et al*. (1994) investigated chemical analysis of industrial effluent of Balaju Industrial District and effluent from a brewery industry, tannery industry and dyeing industry all situated in Kathmandu valley. The results indicated that Balaju industrial district effluent was alkaline and rich in organic waste. Dying, tannery and brewery waste water had elevated temperature where as Chromium concentration in brewery and tannery waste water was found to be more than tolerable level.

Sharma and Upadhaya (1994) analyzed toxic metallic ions in water sample of Bagmati, Dhobikhola and Tukucha and found that the river was being polluted by toxic metallic ions. Possible sources of metallic pollution were industrial effluents which are being discharged into river system without treatment.

Sharma and Shahi (1994) monitored twenty two shallow tube wells along the river corridor of Bagmati, Dhobikhola, Tukucha and Bishnumati in the month of September and October. The study revealed that the shallow ground water of Kathmandu was polluted by non-point source like seepage of waste water from sewers and septic tanks and solid water leachate.

Ghimire (1994) examined the physico chemical parameters of three different industrial effluents of Kathmandu valley i.e. carpet dyeing, tannery and steel. He found that the effluent of carpet dyeing industry had low concentration of various metallic and non metallic components with moderate range of pH where as the effluent of tannery and steel industries had high concentration of metallic as well as non metallic components with high pH and conductivity.

Poudel and Upadhya (1995) analyzed water qualtity of Bagmati river Chovar, Bagmati river Shankhamul and Manohara Khola. The result showed that Manohara Khoala was comparatively less polluted than Bagmati. The Bagmati river water at Chovar was highly polluted.

Prasad (1995) analyzed the water quality of Bagmati river at six sites. He found maximum BOD of 200 ml/l at site E (near the suspension bridge joining Kupondole and Teku and minimum BOD of 28 mg/l at site A (Sundarijal in the upper part river course). Similarly maximum DO of 9.6 mg/l was recorded at site A and minimum DO at 2.1 mg/l at site E.

Anonymous (1996) analyzed river water quality in the Kathmandu valley, the Pokhara valley and the Terai regions from 1992 to 1995. The result revealed that Bagmati, Bishnumati, Dhobikhola, Manohara and Hanumanti river were highly polluted. Major physico chemical parameters like BOD, COD, NH_4, NO_3 and NO_2 were very high and COD value was the maximum i.e. 1350 mg/l at Tankeswari in Bishnumati.

Rajukkannu *et al*. (1997) studied the use of distillery and sugar industry waste water in agriculture and formulated the range of various parameters of distillery effluent such as BOD, COD, N, P, K, TDS, pH and heavy metals and well documented the beneficial effect of spent wash.

Jha and Niroula (1998) made comparative study of pollution load of different industries located at Biratnagar. Himalayan soap and chemical industry had the higher amount of dissolved solutes (145.1 mg/l), lowest oxygen (0.09 mg/l) and extreme pH (11) range. Similarly, Hulash wire effluent had acidic pH but the amount of dissolved oxygen (2.9 mg/l) was near the tap water (3.2 mg/l). Other effluent as well as municipal sewage had pH range 0.5 to 3.7.

Anonymous (2000) reviewed the effluent from metal industries tend to be acidic and have various pollutants such as phenol, fine suspended solids, chromium, mercury, nickel, lead, copper and cadmium, However, the specific contaminant and concentration depend solely on the particular manufacturing processes used. Effluents from the textile manufacturing process, generated from the washing out of the impurities in the fibre, contain organic compounds and are extremely alkaline. Food processing wastes from meat, diaries, brewery distillery and the canning operations generate large amount of organic by products which are disposed in the river water.

Sha *et al*. (2000) made a comparative study on physicochemical properties of the three industries ie. brewery, paper and distillery and their use in agricultural land along the Narayani river. She found that effluents from brewery and paper industries were fairly good than distillery effluent for irrigation.

Dixit (2001) examined the water of Bagmati river in Kathmandu valley in most reaches in urban and down stream areas was highly polluted particularly in the dry season. The river mostly received pollutants from municipal and industrial waste and was of organic in origin. Most of the parameters of river water were found to exceed the WHO permissible limit of drinking, domestic and fisheries.

Shrestha (2002) analyzed the physico-chemical parameters of the Bishnumati river of Kathmandu valley. He found that Bishnumati river was polluted by different chemicals and effluent from the various anthropogenic sources such as industrial effluent, domestic sewages, unburned fossil fuels.

Most of the parameters were found above the level of WHO standard and he also concluded that the pollution load was found increasing slowly from upstream sites of the river to downstream.

Banerjee *et al*. (2004) studied biomethanation of distillery wastes and its mathematical analysis. He found that distillery wastes from alcohol manufacturing unit are highly polluted with organic substance. Hence it is necessary to decrease the pollution load to have eco- friendly environment.

Jain *et al*. (2005) studied the impact of post methanation distillery effluent irrigation on ground water quality. The study concluded that the organic and inorganic ions added through the effluent could pose a serious threat to the ground water quality if applied without proper monitoring.

Bustamanate *et al*. (2005) analyzed the uses of winery and distillery effluents in agriculture and found that the above effluents showed an acidic pH, a high micronutrient and heavy metal content. Some of the parameters were found not compatible with agricultural requirements; therefore, conditioning treatment of these effluents was necessary to produce a safe, stable and easily manageable end product.

Mwinyihija *et al.* (2006) studied an eco-toxicological approach to assessing the impact of tanning industry effluent on river health. The study concluded that the biogeochemistry of river system impacted by industries discharging effluent into them and the invaluable role of a biosensor based eco-toxicological approach to address effluent hazards particularly in relation to river sediments.

2.2 Effect of Effluent on Plant Growth and Development

There are numerous studies on the effect of effluent on plant growth and development. A selected few are reviewed here.

Puerner and Siegel (1972) studied the effect of effluent on seedlings growth and found that compounds of Hg, Zn, Ag, Cd, Pb and Pt inhibit seedling growth followed by disorientation.

Koc *et al*. (1976) observed that the tannery industry produced large amount of sludge which can be used as a source of low, acting nitrogen but it contains appreciable amount of chromium. Lee *et al*. (1976) study the effect of effluent on the seedlings growth and found that higher concentration of Cadmium reduced the plant growth but lower concentrations had no toxic effect.

Webber (1981) studied the effect of heavy metal pollution on plant and found that many industries produce waste, which contains trace metals either in the form of liquid effluent or as solid residues. Many liquid wastes are directly discharged into the sewers and the metals contained are eventually concentrated in sewage sludge, which may be applied to the land as manure or soil conditioners.

Jerath and Sahai (1982) studied the toxic effluent of fertilizer factory effluent containing high concentration of various forms of nitrogen on seed germination and seedling growth of maize. Sahai *et al*. (1983) observed the effect of distillery waste on seed germination and seedling growth of rice (*Oryza sativa*) and found that the effluent concentration more than 25 percent significantly retarded both germination percentage and seedling growth. They found that root growth was more adversely affected than the shoot growth by the effluent. They concluded that distillery effluent contained excessive amount of various forms of cations and anions might be injurious to germination and seedling growth.

Chaudhary (1983) observed that concentration above 5% of the effluent from Bansbari leather and shoe factory, Kathmandu, suppressed seed germination, seedling growth, fresh weight, dry weight and biochemical products of wheat *(Triticium aestivum)* and rice *(Oryza sativa)*. He concluded high concentration of chromium and high pH present in the effluent may be the chief cause for such inhibitory effect.

Woolhouse (1983) studied the effect of effluent on growth and development of rice and reported that abnormal level of iron adversely affects the growth and causes other physiological disorders in rice (*Oryza sativa*). The excess supply of heavy metals (Mg, Zn, Mo, Co, Ni, Cd, Cr etc) has been shown toxic to a wide variety of plants.

Sahai and Neclam (1987) studied the effect of various concentration of the mixed fertilizer factory and distillery effluent on the germination of seed and seedling growth of *Phaseolus radiatus* Linn. They concluded that the mixture of fertilizer factory and distillery effluent was found beneficial up to 15 percent of the overall growth of the plants and reported this mixture effluent was suitable for the irrigation purpose.

Chaudhary *et al*. (1987) and Shrivastava and Mathur (1987) reported that industrial effluents at higher concentration suppressed and at low concentration promoted germination and growth in agricultural and vegetable crops. Thakural and Kaur (1987) analysed the effect of some trace elements of polluted water on the germination of *Cymoposis tetragonoloba* Toub. They concluded that low pH value of effluent may be the main cause for the greater effect on the seedling growth.

Kummerova, *et al*. (1989) studied the effect of effluent on *Lactuca sativa* and found that Manganese (Mn) inhibited the growth of root and hypocotyle. Cheung, *et al*. (1989) studied the root and shoot elongation as an assessment of heavy metal toxicity and Zn equivalent value of edible crops. The shoot elongation was found to be less sensitive to metal than root elongation.

Bahadur and Sharma (1990) studied the effect of industrial effluent on seed germination and early seedling growth of *Triticium aestivum* L. They observed significant decrease in percentage of germination, shoot length and root length and shoot length was much more affected than the root length. Kumar *et al*. (1990) investigated the effect of Saurastra chemicals effluent (oil, grease, phenols, calcium, magnesium, chloride, sulphate etc.) on germination and growth of Guar (*Cymopsis tetragonaloba* Toub.) and found no germination in undiluted effluent. Effluent of 25% concentration retarded the growth.

Noggle and Fritz (1991) reported that the quality of the water has the vital role, which influences the seed germination because of the presence of moisture and aqueous environmental conditions. Germinating seeds are highly sensitive to foreign materials so that highly polluted effluent from industry often prevents seed germination. Biney (1991) used the method of seed germination to characterize natural and waste water. He reported the maize (*Zea mays)* seeds more sensitive to differences in water quality than cowpea seeds.

Chapagain (1991) studied the effect of seedlings growth of vegetable crops. The study concluded that the toxicity of polluted water of Dhobikhola containing tannery industry waste and sewage waste was also associated with inhabitation of seed germination and seedling growth of vegetable. However, the magnitude of toxicity varied with the species. Ramanujan (1991) studied the inhibitory effect of sewage waste containing industrial discharge on seed germination and seedling growth of *Phaseolus mungo* and found inhibition in the seed germination and seedlings growth by industrial discharge.

Mishra and Behera (1991) studied the percentage of germination, and growth pigment content of rice (*Oryza sativa* L). The study reported that seedling decreased significantly with increase in the effluent concentration of paper industry. Patel and Kumar (1991) analyzed the germination experiment of mustard (*Brassica juncea* L.) soaked in different concentration: 10, 20, 30, 40, 50 and 60 percent of the effluent of pharmaceutical factory and found that the increasing concentration (above 20%) of effluent induced a gradual decrease in the germination percentage, seedling growth as well as pod production.

Swaminathan and Vaideswaran (1991) found that the dying factory effluent favoured seed germination but higher concentrations (above 50%) retarded seedling growth of groundnut. Sharma and Naik (1991) studied the effect of a steel mill effluent in *Abelmoschus esculentsu* (L) moench. in its germination parameter (% of germination, speed of germination, germination, relative index and seedling growth). They found more than 7 percent decrease in germination and about 12 percent, 30 percent and 33 percent in seed germination, germination relative index and seedling growth, respectively.

Goel and Kulkarni (1994) investigated the effect of a sugar factory waste on germination of gram seed (*Cicer arietinum*) and concluded that the industrial effluent at higher concentration suppressed and at low concentration promoted germination and growth of agricultural and vegetable crops. Pandey and Soni (1994) examined the effect of different concentrations of distillery effluent on germination of three multi useful tree species *Acacia catechu, Dalbergia sissoo* and *Morus alba* which grow abundantly under tropical and subtropical climatic conditions. Experimental findings indicated that seeds of *A. catechu* were more resistant and more vigorous than *D. sissoo* and *M. alba.* An effluent concentration of 10 percent was more favourable for seed germination compared to ordinary water.

Barbafieri *et. al* (1996) found that the excess supply of heavy metal (e.g. Mg, Cu, Zn, Mo, Co, Ni, Cd, Cr etc.) had been toxic to a wide variety of plants. Pokharel *et al* (2000) studied about the toxic effect of some industrial effluent (Hulas Wire Industry, Shah Udhyog and Strawboard Industry) on *Allium cepa*. The result showed that the root growth and number of roots per bulb were adversely inhibited in all effluents compared to control. The highest relative toxicity and root growth was found in 100 percent concentration effluent of Hulas Wire Industry and in all the cases, they concluded that the 100 percent concentrated effluent had more toxic effect than the other lower concentration.

Pokherel and Lekhak (2001) studied the effects of different concentration of lead (Pb) on seed germination, seedling growth and moisture content in three vegetable crops, *Raphanus sativus, Brassica oleracea* var *botrytis* and *Brassica juncea.* The effect of Pb on seed germination differed according to the test species and concentration of treatments. The study showed increase in accumulation of Pb with the increased concentration. Roots accumulated more Pb than the shoots.

Acharya (2001) studied that effect of Brewery industrial effluent on seed germinations of two crops *Triticum aestivum* and *Brassica compestris.* She found that the germination was promoted during early hours at lower concentration (25% and 50%) whereas totally suppressed at higher concentration. Kannan (2001) investigated the effect of distillery effluents on crop plants. The results showed that the germination percentage was zero in 100 percent effluent irrigations where as the percentage of seed germination in control was 100. From this study, the 1 percent effluent and 5 percent effluent irrigation was recommended to increase the vigour index of the crop plants.

Sharma *et al*. (2002) carried out bioassay studies to assess the toxicity of distillery effluent on seed germination, seedling growth and pigment contents and found higher concentration (>5%) of effluent were toxic but study also reported that effluent can be used for irrigational purpose after proper dilution.

Tomer *et al*. (2002) studied the physico chemical characteristics of distillery effluent and the effect of its various concentrations on the seed germination of *Helianthus annus* in western Uttar Pradesh. High temperature, acidic pH, excessive quantities of inorganic, organic matter and total solids in the spent wash causes soil salinity and high osmotic pressure of the soil solution after irrigation and decreased the seed germination drastically.

Misra and Pandey (2002) conducted the germination test in the laboratory to investigate the effect of distillery effluent and leachate on the growth of *Cicer arietinum.* Seeds of *Cicer arietinum* exposed to the concentration of effluent (10 to 50%) and concentration of lechate of flash light factory sludge (5%) of 20 percent was found to be beneficial for the growth of root and shoot as compared to control. However, the concentration of effluent/leachate 100 percent was found to be inhibitory.

Pandey and Neraliya (2002) studied the impact of distillery effluent on seed germination and seedling growth (root and plumule length) of Bengal gram, *Cicer arietinum* Linn at various concentration for different days. There was increment in above parameters at lower concentration (10%, 20% and 40%) while a decrement was observed at higher concentrations (60%, 80% and 100%) after exposure. The study concluded that chlorophyll and protein content are very sensitive to pollutant and thus can be used as bio-indicators of water pollution.

Ramana *et al*. (2002) studied effect of distillery effluent on seed germination in some vegetable crops and found that the distillery effluent did not show any inhibitory effect on seed germination at low concentration except in tomato and bottle guard. Irrespective of the crop species at higher concentrations (75% and 100%), complete failure of germination was observed. They concluded that the effect of the distillery effluent is crop-specific and due care should be taken before using the distillery effluent for pre-sowing irrigation purpose.

Neupane (2003) examined the effect of distillery effluent on seed germination and seedling growth of *Oryza sativa* and *Triticum aestivum*. He concluded that the inhibitory effect on seed germination was more in higher concentration in both the test crops.

Chandra *et al*. (2004) analyzed the impact of anaerobically treated and untreated (raw) distillery effluent irrigation on soil microflora, growth, total chlorophyll and protein content of *Phaseolus aureus.* From the study it has been concluded that lower concentration of the raw distillery effluent (1-5%) and treated distillery effluent (1-10%) had stimulated the growth of *P. aureus* and soil microflora except soil bacteria. However, concentrations of raw distillery effluents (10-20%), treated effluent (15-20%) had toxicity to test parameters.

Malla and Mohanty (2005) studied the effect of paper mill effluent on *Phaseolus aureus* Roxb. The effluent significantly inhibited germinations of root and shoot length. The shoots of the seedlings were found to be resistant where as roots of the seedlings were susceptible to paper mill effluent treatment.

Bhargaua and Bhargaua (2005) investigated the effect of paper mill effluent on seed germination and seedling growth of *Vicia faba* L. The results revealed that the effluent concentration promoted both seed germination and seedling growth.

Sharma *et al*. (2006) studied the effect of Pragati Paper Mill Industry effluent on chlorophyll content of some medical plants such as *Calotropis* *procera* R.Br. and *Solanum xanthocarpum* Schard & Wendl. The chlorophyll content showed a decreasing trend in the selected plants growing around the industry, under the impact of paper mill effluent as compared to plants irrigated with normal water (pH.3.6) with higher BOD and COD.

2.3 Effect of Effluent on Soil

Soil plays an important role to determine the growth of plants. It has been a common practice of industries and factories to discharge the effluents into nearby water resources. Such water resources contaminated by effluents are used by farmers to irrigate their crop field. This irrigation with effluent mixed water deteriorates the quality of the soil and there by decrease the crop production.

Tripathi *et al*. (1978) studied the effect of chemical effluent discharged from a chemical fertilizer factory on physical properties of soil and found that cations exchange capacity, parasite and water holding capacity were reduced by effluent.

Juwarkar and Dutta (1990) examined impact of distillery effluent on soil microflora. The study concluded that raw distillery waste water was very toxic to the soil micro organisms which are important in the soil ecosystem. Sharma *et al*. (1990) studied the physico-chemical properties of steel plant waste water and its effects on soil and plant characteristics. It was found to have very high concentration of NO_2, NH_4, iron and phenol. They also reported that concentrations of calcium and magnesium decreased and concentration of total nitrogen, sulphur and phosphate increased in the effluent irrigated soil.

Pathak *et al*. (1999) studied soil amendment with distillery effluent for wheat and rice cultivation. The study showed that organic carbon and available potassium content of post harvest soils were increased. There was no change in pH after harvest of wheat and rice. The study concluded that the effluent could be used as soil amendment. However, the electric conductivity (EC) of soil increased indicating the possibility of salinity developed in the long run with higher level of effluent application

Sah *et al*. (2000) examined the effluents of Bhrikuti Pulp and Paper Mills, Gorkha Brewery Limtied and Shree Distillery located along the Narayani river in Nawalparasi District. They found that effluent from the paper mill have been seasonally used to irrigate the agricultural fields due to its high content of lignin and organic matter. Such effluent didn't raise salinity and alkalinity of soil in irrigated fields. Similarly effluents from the brewery were found fairly well for irrigation because of its high content of phosphorus.

Acharaya (2001) studied the effects of brewery effluents on soil. She found that except exchangeable potassium all other chemical parameters analyzed were found to be higher in irrigated soil than that of non-irrigated soil. Exchangeable potassium irrigated soil was 336.5 mg/l where as in non irrigated soil it was 447.35 mg/l.

Singh *et al*. (2003) analyzed the effect of distillery effluents on plant and soil enzymatic activities and groundnut quality. The study found that application of distillery effluent did not affect the nitrate reductose activity but BSW (Biomethanated Spent Wash), significantly increased the nitrate content in the rhizosphere soil. The distillery effluent significantly increased dehydrogenase and alkaline phosphate activity more than recommended NPK+FYM (Farm Yard Manure).

Santiago and Bolan (2004) reported that the distillery spent wash is acidic having pH less than 4 and is generally characterised by high level of BOD and COD and nutrient element such as nitrogen and potassium. Hence also used as a source of plant nutrient and organic matter for various agricultural crops particularly under dry land conditions. But indiscriminate disposal of spent wash (effluent) has resulted in adverse impact of soil and environmental health.

Yadav (2006) studied the use of industrial effluents in agriculture-problem and prospects. He generalized that effort should be made in the future for proper treatment and safe disposal of industrial effluent and use in agricultural land in order to increase food grain, production and enhancing environmental quality

2.4 Environmental Justice

It has been found that no research was carried out in the name of environmental justice in Nepal except very few legal studies (Adhikari and Ghimire, 2002). In spite of having no any specific studies on environmental justice, many works and studies related to environment and natural resource management included different aspects of environmental justice. Environmental justice in Nepal is related to forests, soil, solid waste, water, air and environmental degradation has emerged as a major global concern for human survival (Anonymous, 2003).

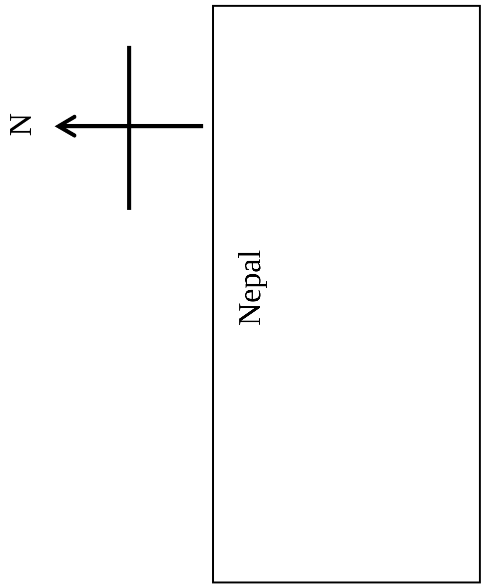
Chaudhary and Jha (2003) have summarized important issues of environmental justice and social equality in the context of Nepal, which are (1) over population, poverty and pollution, (2) environmental castism, (3) food security and sustainable livelihood, (4) unemployment and social injustice, (5) inadequate sanitation, (6) dumping waste, (7) industrial effluent and toxicity, (8) toxic schools, (9) air pollution, (10) water pollution, (11) climatic justice, (12) ecotourism and equity (13) lack of representative in decision making (14) corruption and (15) trans boundary issue and weak enforcement of legislation.

Ghimire (2003) stated that there are several discriminatory and injustice practices in both urban and rural areas of Nepal, varying from disproportionate sharing of ecological benefits and hazards in society, to the unequal access to resources, healthy environment decision making information and other civil rights.

Dixit (2003) reported that the toxic effluents coming out from Kathmandu, Patan and Bhaktapur industrial area is discharged in the rivers. The wastes generated from industries are not usually treated. For example Basbri leather shoes factory discard untreated chromium into Dhobikhola in a big quantity. Upadhaya and Pant (2003) found that most of the industries in Nepal are situated near by the rivers and discharge their waste water/effluent directly into the rivers. Such trend of discharging effluent directly into the rivers has caused environmental injustice to the local people and the farmers who use river water for their life subsistence.

Jha (2006) reported that the problem of water pollution has taken a serious form due to the common practice of discharging industrial effluent in rivers and rivulets without treating. Bagmati and Bishnumati river of Kathmandu, Narayani river of Chitwan and Nawalparasi, Bighi river of Jankapur and Mahottari, Sirsia river of Birgunj are few examples of environmental injustice due to water pollution and the industrial effluent.

Belbase (2006) stated that the Bagmati and Bishnumati rivers in Kathmandu are being polluted by discharge of sewages and effluents from municipality and various industries. Effect can be seen on the farmers who use the river water to irrigate their fields and the fishermen who sustain their livelihoods by fishing in these rivers.



cation of VDCs and Karnali distillery industry

Banke District

3. MATERIALS AND METHODS

3.1 Description of the Study Area

Banke district (Bheri Zone) lies in the southern part in Mid Western Development region of Nepal. It is one of the terai districts situated at an altitude of 152 m and geographically located between 81°29' to 82°80' east longitude and 27°54' to 28°20' north latitude. It has tropical and sub tropical climate and is one of the warm places of Nepal. In summer the place remains very hot exceeding the temperature of 45°C. The rainfall mainly occurs in monsoon season and a short rainfall during winter season. The district consists of 46 VDCs and a municipality. Nepalgunj is its head quarters which is one of the industrial towns of Nepal situated very close to Indian boarders.

Banke is one of the important agricultural production districts of Nepal. The present research work on effect of distillery industry effluent on agricultural crops and soil is based on the effluent discharged by Karnali distillery Pvt. Ltd. located at Khajura Khurd VDC of Banke district. Karnali Distillery Pvt. Ltd. was previously known as Shree distillery Pvt. Ltd. It was established in 1985 A.D. It is situated at ward No. 2 of Khajura Khurd VDC. The distillery is surrounded by cultivated field and human settlements. It is just 7 km far from Nepalgunj town.

The distillery produces about 3000 litres of spirit per day. The factory imports its raw materials (molasses) from Birgunj, Chanauta and Rautahat. The total water input by the distillery for various purposes is about 50,000 litres per day. This distillery discharges about 40,000 litres of effluent (Spent wash) per day.

Previously the distillery used to discharge its effluent directly into a stream nearby the distillery called Kiran Khola through a canal without treating. At present the distillery has made four reservoirs having the capacity of 25,000 litres each to collect its spent wash. These reservoirs are within distillery area and are being used as lagoons where the collected effluent gets settled to some extent before it is discharged. But these are only the temporary system to manage the huge amount of effluent.

The collected effluent (spent wash) is usually discharged into the stream during rainy seasons. But if the reservoirs are full, the distillery discharges its effluent in other seasons also.

The effluent (spent wash) collected directly from the reservoir is the source of effluent for this present research. For the comparative study of the pollution of distillery effluent in the study area, two VDCs have been selected on the basis of agricultural crops grown in the area and use of distillery effluent for the irrigation purpose.

The two VDCs are Khajura Khurd VDC and Bageshwari VDC. Both VDCs located near to the distillery factory are the main areas for agricultural crop production of the district. The farmers of Khajura Khurd VDC located upstream of the factory do not use effluent mixed polluted water for irrigation where as Bageshwori VDC situated downstream of the factory use the effluent polluted water frequently for irrigation.

Socio-Economic Condition

The main occupation of the people of the study area is farming. Hence the economy of the people is mainly based on agriculture. Mix community of Magar, Chhettri, Brahmin and Dehati inhabit the study area. Rice, wheat and legume plants are the major agricultural crops of the study area. Most of he households are fully dependent on farming for their life subsistence. Farmers of both the VDCs depend upon the water of the Kiran Khola for irrigation.

The total population of Bageshwori VDC was found to be 12,413 with 2,382 households where as population of Khajura Khurd VDC was 5180 with 917 households (CBS, UNFPA Nepal, 2002).

3.2 Test Seeds

The seeds of the rice (*Oryza sativa*), variety was ‘Barse 3004’ and wheat (*Triticum aestivum*) the variety was ‘Bhrikuti were obtained from regional agricultural research station Khajura, Nepalgunj. These seeds were selected on the basis of crops cultivated by the local farmers of that area. The seeds were stored inside airtight plastic bottles at the room temperature.

3.3 Industrial Effluent and Soil

For the present investigation, the effluent of the Karnali Distillery Pvt. Ltd. Khajura, Nepalgunj was used. Soil samples were collected from two sites i.e. effluent irrigated and non-irrigated rice and wheat fields during the month of June and October 2006.

3.4 Sampling of the Industrial Effluent and Soil

The effluents were collected directly from the spent wash (effluent) reservoir of the factory which was considered as concentrated or pure for the present study. In other hand, the effluent mixed in river water collected at the point 100m far from the place of direct discharge to the river had been considered as dilute effluent.

Effluents were collected during the month of June 2006 when the factory was running at full capacity. Effluent samples (10 bottles of for various parameters) were collected in plastic bottles of one litre capacity which were thoroughly cleaned by repeated washing with distilled water and rinsed with the sample water before collection. For the analysis, effluent sample were acidified with HNO_3 ($pH<2$) at the time of collection (Trivedy and Goel, 1986).

Parameters such as temperature, pH, Total Suspended Solid (TSS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Nitrogen (N), Phosphorus (P), Potassium (K), heavy metals like Lead (Pubs), Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe) and Cadmium (Cd), were analysed in the lab. The effluent used for the germination experiment was stored in the dark at the room temperature.

The soil samples were collected from the selected field of two different sites. For sampling about 500 g soil was taken out from 15 cm depth from the four corners and a middle part of the selected field and all those soils were thoroughly mixed and about 500 g of mixed soil was collected in a zipper bag. From each site 2 soil samples were collected.

3.5 Physico-Chemical Analysis of the effluent and Soil

Physico-Chemical analysis of the effluent and soil was carried out in the following laboratories:

a) Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu (Germination experiment of test seeds)

b) Nepal Bureau of Standards and Measures, Balaju, Kathmandu, Nepal (All the parameters of effluent)

c) Soil Science Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal.

   (Nitrogen, Phosphorus, Potassium, Soil pH, Organic Matter, Soil texture and heavy metals of soil collected before and after monsoon)

d) Regional Soil Experiment Laboratory, Khajura, Nepalganj, Banke (Nitrogen, Phosphorus, Potassium, Soil pH, Organic Matter, Soil texture of soil collected before monsoon)

3.6 Method of Effluent Test

All the analytical processes were carried out according to the standard method for the examination of water and waste water (APHA, 1998).

pH

pH was measured by glass electrode method or electrometric method by using pH meter. Before measuring the pH of the effluent sample, the pH meter (Metrohm pH/Ion meter) was standardized or calibrated by dipping the electrode into standard buffer solutions.

Temperature

Temperature of the effluent sample was recorded on the spot by using mercury thermometer following Gupta (2000).

Total Suspended Solid (T.S.S.)

For the determination of T.S.S. at first micro glass fibre filter was kept in a perforated porcelain crucible. Then initial weight of the glass fibre filter was taken. After then 100 ml well mixed effluent sample was taken and filtered with the help of succession pump. The residue retained on the filter was dried to a constant weight at 103°C to 105°C. Then again, the weight of filter with the dried residue was taken. The weight difference between initial and final was estimated to calculate the T.S.S. Following formula was used to calculate T.S.S.

$$\text{Total suspended solids (mg/l)} = \frac{(A - B) \times 1000}{\text{Sample Volume (ml)}}$$

Where,

A = Weight of filter + dried residue in mg.

B = Weight of filter in mg

Dissolved Oxygen (DO)

DO was determined by using the BOD bottles of 300 ml. The dissolved oxygen was immediately fixed by adding 2 ml of Manganese sulphate ($MnSO_4$) and 2 ml of alkaline potassium iodide (KI) in the sample. A brown precipitation was formed after the solution was mixed thoroughly which was allowed to settle down completely for about an hour. (APHA, 1998)

Then DO was measured by taking 50 ml of sample water into a conical flask from the BOD bottle and then titrated against sodium thiosulphate solution (0.025 N) until a straw colour appeared. Then a few drops of starch solution were added as an indicator. The titration was continued until the disappearance of the blue colour. The quantity of DO was calculated in mg/l by applying the following equation.

$$DO = \frac{(\text{ml} \times \text{n}) \text{ of titrant} \times 8 \times 100}{\frac{V_2 (V_2 - V)}{V_1}}$$

Where,

V = Volume of $MnSO_4$ and KI

V_1	=	Volume of BOD bottle
V_2	=	Volume of the titrated sample
n	=	normality of titrant

Biochemical Oxygen Demand (BOD)

To determine BOD sample dilution was prepared by 10 times dilution of the sample water with distilled water. Then 1ml of seed (domestic sewage) was added into each litre of sample water for growing micro organism. After then 1 ml each of phosphate buffer, MgSO4, $CaCl_2$ and $FeCl_3$ solutions per litre of water sample was added. The water sample was neutralized to pH around 7 by adding NaOH or H_2SO_4. (APHA, 1998)

The two sets of the BOD bottles having capacity of 300 ml each were filled with prepared sample water. The one set of bottle was kept in BOD incubator at 20°C for five days and another set of the BOD was used immediately for determining DO.

After 5 days incubation, DO of the sample dilution was determined and the difference between initial and final DO was determined by following formula.

$$\text{BOD (mg/l)} = \frac{(DO - DO_5) - (B - B_5)f}{p}$$

Where,

DO	=	Initial dissolved oxygen of diluted sample.
DO_5	=	Dissolved oxygen of diluted sample after 5 days incubation at 20°C, mg/l
B	=	DO of seed control before incubation, mg/l
B_5	=	DO of seed control after incubation mg/l
f	=	Ratio of seed in diluted sample to seed in seed control i.e. % seed in diluted sample percent seed in seed control.
p	=	Decimal volumetric fraction of sample used

Chemical Oxygen Demand (COD)

It is determined by open reflux method in which organic matter was oxidized by a boiling mixture of chromic and sulphuric acids (APHA, 1998). Following formula was used to calculate the COD.

$$\text{COD (mg } O_2/l) = \frac{(A - B) \times M \times 8000}{\text{ml sample}}$$

Where,

A = ml FAS used for blank

B = ml FAS used for sample

M = Molarity of FAS and

8000 = Milli equivalent weight of oxygen × 1000 ml/L.

Nitrogen (N_2)

Total Nitrogen content in the sample water was determined by the Micro-Kjeldahl method with kjeltic modification in which water sample was digested with the help of conc. H_2SO_4 in the presence of $CuSO_4$ and K_2SO_4 catalyst at low temperature for about 2-3 hours while doing this amino nitrogen of organic materials in the sample water was converted to ammonium. The digestion and distillation of the sample water was done in kjeldhal distillation flasks with a capacity of 800 ml.

After addition of alkali NaOH into the digested sample, all the nitrogen in terms of ammonium salt was trapped in boric acid by the special kjeltic distillation unit. After then the total nitrogen absorbed in boric acid was determined by titrating the distilled sample water with 0.01N HCl.

Phosphorus (P) (Ascorbic Acid method)

The total phosphorus content in the sample water was determined by applying the ascorbic acid method in which ammonium molybdate and potassium antimonyl tartrate reacted in acid medium with orthophosphate to form a heteropoly acid phasphomolybdic acid that was reduced to intensely coloured molybdenum blue by ascorbic acid (APHA, 1998).

Potassium (K) (Flame Atomic Absorption Spectrometry Method)

Potassium was determined by the flame atomic absorption spectrometry method in which potassium was estimated by the direct aspiration into an air-acetylene flame. The characteristic radiation for potassium is 766.5 nm. The intensity of which was read on a scale by using a filter for this wavelength.

The amount of energy at the characteristic wavelength absorbed in the flame was proportional to the concentration of the element in the sample over a limited concentration range (APHA, 1998).

Heavy Metals (Atomic Absorption Spectrometry)

The heavy metals Pb, Fe, Zn, Cu, Cd and Mn present in the effluent sample were determined by Atomic Absorption Spectrometry. In this method specific hollow cathode, lamps were used for determining specific heavy metal. (APHA, 1998)

3.7 Method of Soil Analysis

The quality of soil in agricultural land to a certain extent depends upon the type of irrigation. It has been found that the field irrigated by industrial effluent leave several effects in the soil. Since the high amount of certain chemical from the effluent is toxic to the plants, certain selected physico-chemical characteristics of the sampled soil was analyzed by applying standard method. The collected samples from each five sub-plot were mixed in order to make 2 samples from each of the two selected sites and sieved through 2.36 mm sieve before analysing.

pH

The pH of the soil sample was determined in 1:2 soil water suspensions with the help of pH meter using glass calomel electrode.

Organic Matter

It was determined by Walkley and Black's rapid titration method (1934) in which 2 g of soil sample was treated with $K_2Cr_2O_7$ in presence of conc. H_2SO_4 to oxidize the soil organic carbon. The unreduced amount of chromic acid was estimated by titration with ferrous ammonium sulphate in presence of diphenylamine indicator or sodium fluoride. At the end point colour of the suspension changed from violet blue to bright green. Simultaneously a black is run without soil.

$$\text{Organic carbon in soil sample (\%)} = \frac{0.003 \times 10\,(B - C) \times 100}{B \times S}$$

Where,

B = Titration reading with blank

C = Titration reading with soil

S = Wt. Of soil (g)

Nitrogen (N_2)

It was estimated by Kjeldahal method in which the soil sample was digested with H_2SO_4 in presence of $FeSO_4$ and $CuSO_4$. After digestion, ammonia was formed which was distilled with NaOH and absorbed in a known excess volume of 0.1 N H_2SO_4. This percentage of nitrogen was estimated from the volume of 0.1 N H_2SO_4 used for the absorption of ammonia which was known by titrating the excess H_2SO_4 against a standard alkali using methyl red indicator. Total nitrogen content in percentage was calculated by following Bajwa *et al*. (1997).

$$N_2\,(\%) = (20 - x) \times 0.0014 \times \frac{250}{V} \times \frac{100}{W}$$

Where,

x = Vol. of 0.1 NaOH required to neutralize the excess of acid

V = Vol. of filtrate used for distillations

W = Wt. of soil taken for digestion

Phosphorus (P)

Available phosphorus was estimated by Olsen's sodium bicarbonate (pH 8.5) solution extraction method. The blue colour of phospharus ammonium melybdate complex in an acidic medium containing stannous chloride was determined by spectrophotometer at the wavelength of 660 nm by following *Bajwa et al.* (1997).

Phosphorus (kg/ha) = F × R

Where,

F = Reading in spectrophotometer

R = Coefficient factors calculated from blank solution.

Potassium (K)

It was determined by flame photometer method by using following equation.

Potassium (kg/ha) = R X 26.88

Where,

R = Reading in photometer

Soil texture (Mechanical analysis)

It was carried out by the standard hydrometer method.

Heavy metals

For the determination of Heavy metal (Pb, Cd, Fe, Zu, and Cu) present in the soil sample, 10 g of the soil sample was weighed and mixed with the 100 ml distilled water in a clean bottle.

The bottle was shaken well to mix the soil well in the water. The solution was then used to analyze all the above heavy metals of soil as in the case of effluent (APHA, 1998).

3.8 Germination Experiment

The germination tests were carried out in Petri dishes following the method of Kansakar and Bajracharya (1978), Tamot (1979) and Thapa (1994). For germination experiment the healthy and uniform sized seeds were selected and thoroughly washed with distilled water thrice. The seeds were sterilized with the help of 1 percent sodium hypochlorite solution. Then 10 seeds were sown at equidistant in sterilized 10 cm Petri dishes lined with Whatman filter paper. Ten replicas were used for each treatment. Then 5 ml of filtered undiluted (100%) or diluted (1%, 5%, 10%, 25%, 50%) effluent solution was added into each Petri dish. A control experiment was carried out using distilled water. Germination experiments were carried out at 26 ± 2°C in the dark. Then 1 ml of effluent was added at an interval of three days to keep the level of effluent constant.

Seed Germination

The percentage of seed germination was determined at the interval of 24 hours for five days. The emergence of radicle upto 2 mm in length was considered or taken as a criterion for germination (Street and Opik, 1976).

Measurement of Seedling Growth

For the study of seedling growth respective root and shoot length were measured with the help of milimeter scale at an interval of 5 days for each treatment for 15 days. After 15 days seedlings were taken out from each petridishes and their respective root and shoot length were measured, while measuring root length, only the main root (primary root) was taken into consideration. The secondary or auxiliary roots were not measured.

Estimation of Fresh and Dry Weight of Seedlings

For the estimation of fresh and dry weight the seedling components were separated into root (radicle) and shoot (plumule) and measured separately for their fresh weight. These seedling parts were dried in an oven for 48 hours at

75°C and their respective dry weight was taken by using electronic balance (0.001g capacity).

Analysis of Relative Degree of Enhancement of Inhibition

Relative degree of enhancement or inhibition in percentage of each effluent concentration on seed germination, seedling growth, fresh weight and dry weight of seedling of rice and wheat was calculated to determine the degree of enhancement or inhibition over control, by applying the following formula (Chapagain, 1991; Ghimire, 1994).

$$\text{Relative Degree of Enhancement in Inhibitions (\%)} = \frac{x - y}{x} \times 100$$

Where,

X = Germination percent or seedling length or dry and fresh weight of seedling at control.

Y = Germination percentage or seedling length or dry and fresh weight of seedling in different concentration of effluent at the same hour of incubation.

3.8 Statistical Analysis

Analysis of variance is the major statistical tool used in the study for testing the statistical significance of the variance of mean at 5% level. Overall statistical analysis (F-test) of the present study was done following Sharma and Sharma (2002) and statistical programme for social studies (SPSS 10.1).

3.9 Interview with Local People

Altogether twenty local farmers from site A (Irrigated with unpolluted stream water) and site B (Irrigated with Effluent polluted stream water) were interviewed with the help of standard questionnaire by Participatory Rapid Appraisal (PRA) method to verify their awareness about the effect of the effluent and environmental justice. The lists of the questionnaires prepared have been annexed in appendix VII.

4. RESULTS

4.1 Physico-Chemical Parameters of Effluent

Effluent from the Karnali Distillery Pvt. Ltd., Khajura, Banke was dark brown in colour with strong odour. All the phisico-chemical characteristics of the effluent are shown in Table 1.

Table 1: Pysico-Chemical Characteristics of Effluent from Karnali Distillery Pvt. Ltd. and its Associated Stream Water

S. N.	Parameter	Unit	Concentrate	Dilute	Unpolluted Stream water
1.	Temperature	°C	105	36	30
2.	pH	-	3.7	4.0	6.2
3.	Total suspended solid	mg/l	32311	2033	450
4.	Dissolved Oxygen (DO)	mg/l	0.36	2.9	5.2
5.	Total Nitrogen	mg/l	465	335	12.2
6.	Phosphate	mg/l	141.4	3.9	0.3
7.	Potassium	mg/l	5440	1000	16.8
8.	Biochemical Oxygen Demand	mg/l	47520	15450	105
9.	Chemical Oxygen Demand	mg/l	58400	32100	152
	Heavy Metals				
1.	Iron (Fe)	mg/l	115	102.4	4.7
2.	Manganese (Mn)	mg/l	6.4	5.7	0.6
3.	Lead (Pb)	mg/l	0.56	0.29	0.01
4.	Copper (Cu)	mg/l	0.14	0.05	0.04
5.	Zinc (Zn)	mg/l	3.1	1.21	0.06

6.	Cadmium (Cd)	mg/l	7.5	5.2	0.31

The temperature of concentrate effluent of Karnali distillery was recorded 105°C. The temperature of dilute effluent was found 36°C where as the temperature of the up-stream water was recorded only 30°C. The effluent of Karnali distillery was highly acidic in nature with pH value of 3.7 and 4.0 in concentrate and dilute effluents respectively. In contrast to this the pH value of the unpolluted stream water was found to be 6.2 which was less acidic than that of other two concentrate and dilute effluents.

The total suspended solid of the concentrate and dilute effluents were 32311 mg/l and 2033 mg/l respectively where as that of non-polluted stream water was found to be only 450 mg/l. Dissolve oxygen was found to be 0.36 mg/l and 2.9 mg/l in concentrated and dilute effluent respectively. DO value for unpolluted stream water was analyzed 5.2 mg/l.

The N, P, K contents were found to be 465 mg/l, 141 mg/l, 5440 mg/l respectively in concentrate and 335 mg/l, 3.9 mg/l, 1000 mg/l respectively in dilute effluents but the total average content of N, P, K for unpolluted water was found to be 12.6 mg/l, 0.3 mg/l, 16.8 mg/l respectively.

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values for concentrate effluent were 47520 mg/l and 58400 mg/l respectively and that of dilute effluent were 15450 mg/l and 32100 mg/l respectively. BOD and COD values of unpolluted water were calculated as 105 mg/l and 152 mg/l respectively.

The iron (Fe) content was detected 115 mg/l and 102.4 mg/l in concentrate and dilute effluent respectively. But in case of unpolluted water it was found to be 4.7 mg/l. The Maganese (Mn) content of concentrate and dilute effluent was analyzed to be 6.4 mg/l and 5.7 mg/l respectively where as in unpolluted stream water it was found to be 0.6 mg/l. The lead (Pb) content was found to be 0.56 mg/l and 0.26 mg/l in concentrate and dilute effluent respectively where as in unpolluted stream water it was 0.01 mg/l only. The copper (Cu) content was analyzed to be 0.14 mg/l and 0.05 mg/l in concentrate and dilute effluent respectively where as it was 0.04 mg/l in unpolluted water. Similarly, the Zinc (Zn) content in concentrate and dilute effluent were found to be 3.1 mg/l and 1.21 mg/l respectively. Where as in unpolluted streams water it was found to be 0.06 mg/l.

4.2 Effect of the Karnali Distillery Effluent on Soil Characters

The chemical characteristics of the soil (irrigated and non-irrigated with the distillery effluent polluted water) are shown in Table 2.

Table 2: Chemical Characteristics of Soil from Effluent Irrigated and Non-Irrigated Area

			Before Monson		After Monson		Average	
S.N.	Parameter	Unit	Site A	Site B	Site A	Site B	Site A	Site B
A.	**General**							
1.	pH	-	7.5	6.7	7.0	6.2	7.2	6.4
2.	Organic Matter	mg/l	0.51	3.13	0.54	5.04	0.52	4.07
3.	Total Nitrogen	%	0.09	0.16	0.11	0.19	0.10	0.17
4.	P_2O_5 - P	Kg/ha	71.8	228.4	96.0	137	83.9	182.7
5.	K_2O - K	Kg/ha	307.7	940	110	240	208.8	590
B.	**Heavy Metals**							
1.	Iron (Fe)	mg/l	18300	18875	14520	15100	16697	16700
2.	Manganese (Mn)	mg/l	410	477	230	360	320	418.5
3.	Copper (Cu)	mg/l	16	18	15	16	15.5	17
4.	Zinc (Zn)	mg/l	45	32	40	28	42	30
5.	Lead (Pb)	mg/l	10	18	12	15	11	16.5
6.	Cadmium (Cd)	mg/l	28	41	25	40	26.5	40.5

Note: Site A – Irrigated with unpolluted stream water.

Note: Site B – Irrigated with Effluent polluted stream water.

The average pH value of soil irrigated with unpolluted water was slightly lower (6.4) than that of irrigated with polluted with (7.2). The organic matters content in average was higher with the value of 4.07 percent in the soil irrigated with effluent polluted water than in the soil irrigated with unpolluted water with 0.52 percent. Organic matter content of unpolluted soil was less after monsoon where as it was found higher in polluted soil after monsoon.

The nutrients such as nitrogen, phosphorus and potassium were found higher in soil irrigated with effluent polluted water. Potassium was analyzed in sufficient amount in both types of soil. Nitrogen content in average was found slightly higher in the soil irrigated with polluted water (0.17%) than in non-polluted soil (0.1%).

Except Zn all the analyzed heavy metals (Fe, Pb, Mn, Cd and Cu) content was found to be higher in the soil irrigated with effluent polluted water than in the soil irrigated with non-polluted water.

Table 3: Texture class of soil samples of two different sites

Sample	Before Monsoon			Texture class	After Monsoon			Texture class
	% of Sand	% of Silt	% of Clay		% of Sand	% of Silt	% of Clay	
Site A	29	47.1	23.1	Sandy loam	25	40.3	20.5	Sandy loam
Site B	9.8	53.1	37.1	Sandy loam	9.0	50.3	38.4	Silty loam

Note: Site A – Irrigated with unpolluted stream water.

Note: Site B – Irrigated with Effluent polluted stream water.

The texture of soil irrigated with effluent polluted water was found to be sandy loam before monsoon where as after monsoon it changed into silty loam. The texture of the soil irrigated with unpolluted water was sandy loam in both the seasons.

4.3 Effect of Effluent on Seed Germination

Seed Germination

Figures 1 and 2 illustrate the effect of effluent in different concentration on seed germination of rice and wheat, respectively. It was found that the different concentrations of effluent as compared to the control bring about significant change in the rate of seed germination. At lower concentration (1%, 5%) germinations was found to be nearly equal with the control but at higher concentration (10%, 25% in case of rice and 5% in case of wheat) imposed inhibitory effect. It was observed that the seed germination above 25% was not found at all. The rate of seed germination of the two tested crops was significantly affected by different concentration of effluent.

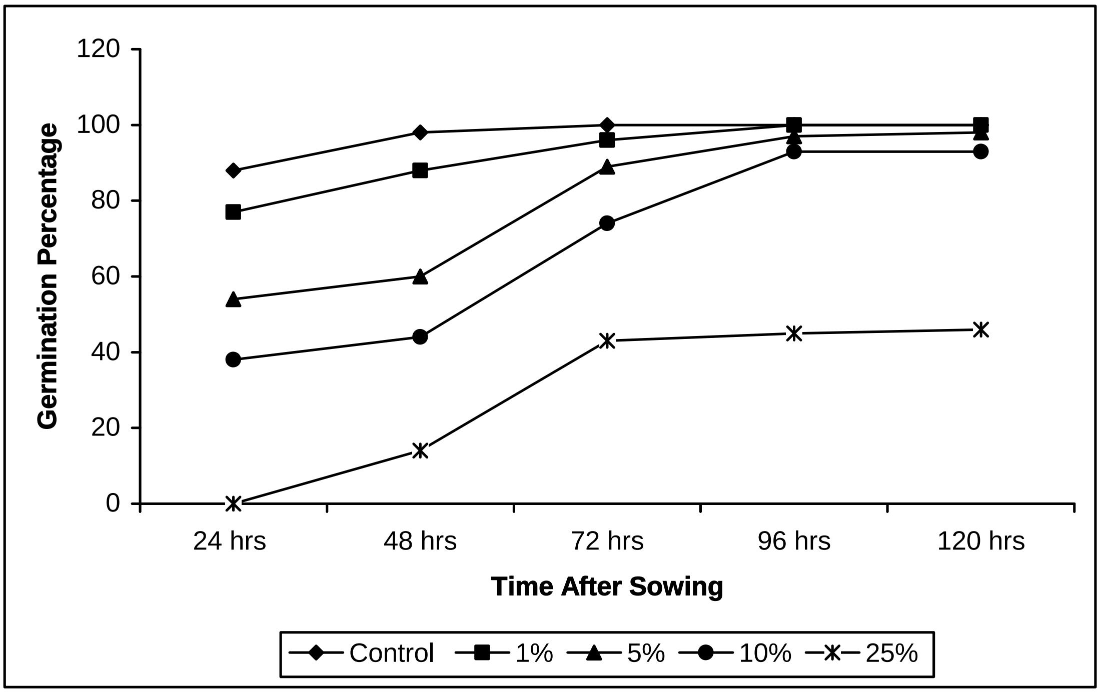


Fig. 1: Effect of effluent on seed germination of *Oryza sativa*. Variance ratio at 5% level Fcal=14.64 and 39.59 (Ftab=3.01 and 3.24) for hours of sowing and treatment concentration at d.f. (4, 16 and 5, 16)

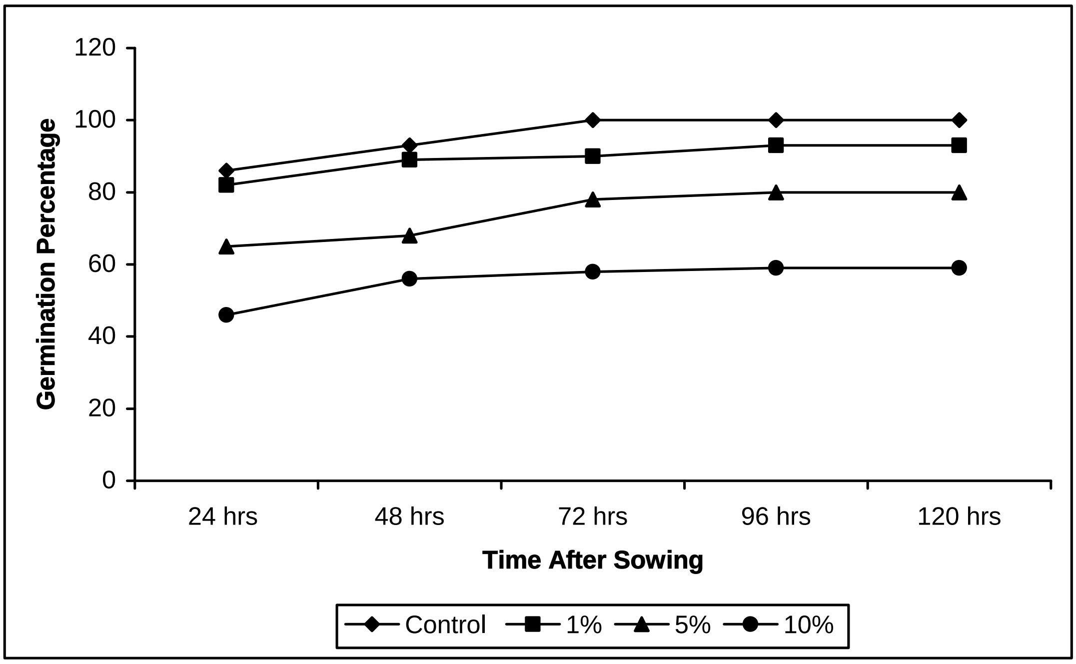


Fig. 2: Effect of effluent of seed germination of *Triticum aestivum*. Variance ratio at 5% level Fcal=14.87 and 205.89(Ftab=3.26 and 3.49) for hours of sowing and treatment concentration at d.f. (4, 12) and (3, 12) respectively.

4.4 Evaluation of Relative Degree of Enhancement or Inhibition by Effluent on Seed Germination

Figures 3 and 4 show the relative degree of enhancement or inhibition on seed germination of test crops by distillery effluent. The effluent had significantly affected the seed germination in early hours of sowing which had been gradually decreased. Higher concentration (10% and 25%) had higher inhibitory effect than that of lower concentration (1%, 5%). Generally the relative value of inhibition decreased with the increase of time period. The relative inhibition for the two test crops was found to be greater in wheat germination than in rice.

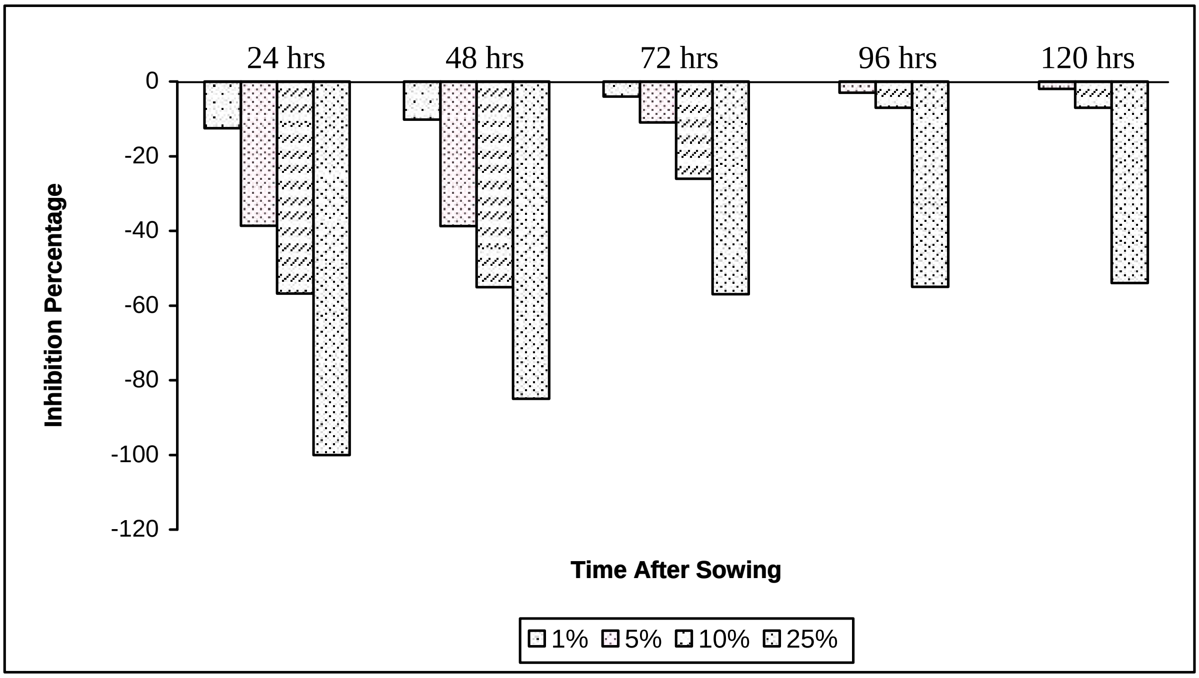


Fig. 3 Relative Degree of Inhibition on Seed Germination of *Oryza sativa* by Effluent

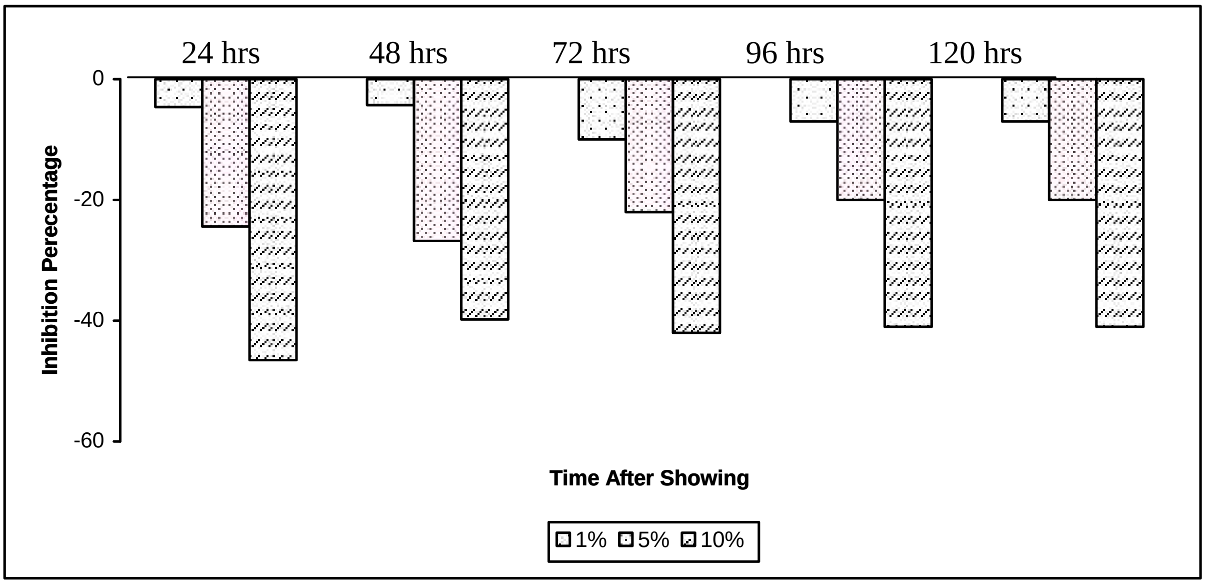


Fig. 4 Relative Degree of Inhibition on Seed Germination of *Triticum aestivum* by Effluent

4.5 Effect of Effluent on Seedling Growth

The effects of effluent on seedling growth of two test crops after 15 days are shown in figures 5 and 6. The result was found to be statistically significant. Lower concentration (1%, 5%) slightly enhanced the shoot growth of rice. In case of wheat shoot growth enhanced at 1 percent only where as higher concentration (10%, 25%) had inhibitory effect. The effect was more pronounced at 25 percent concentration. Comparatively the root growth was more affected than that of shoot.

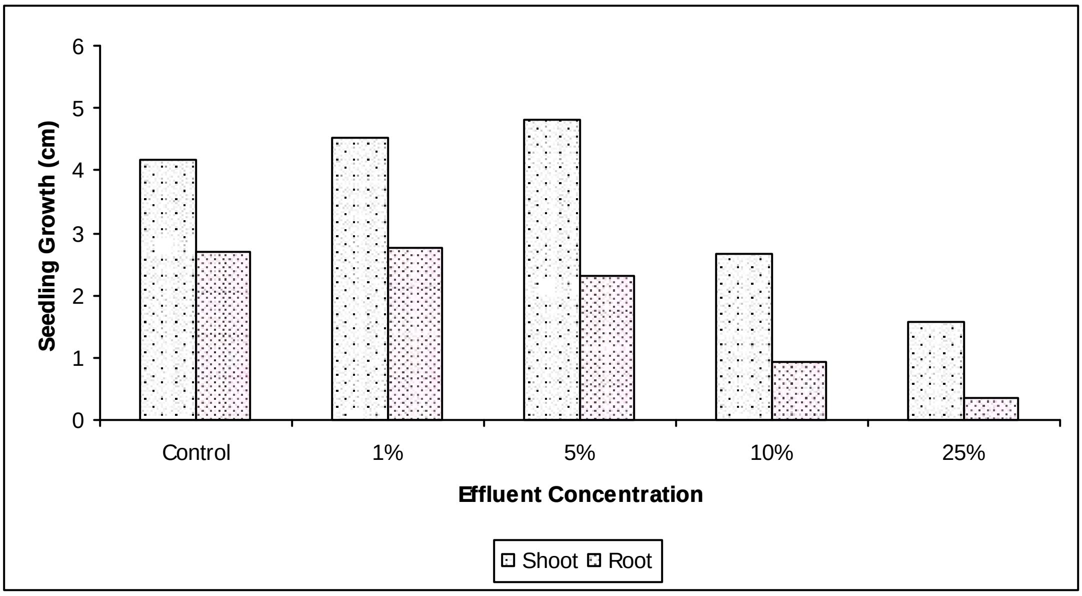


Fig 5: Effect of effluent on seedling growth of *Oryza sativa*. Variance ratio at 5% level, Fcal=9.51,

6.96(F tab=3.84, 4.46) and Fcal 7.24, 5.10(Ftab= 3.84,4.46) for days of sowing and treatment concentration at d.f.(4,8),(2,8) for shoot and roots respectively.

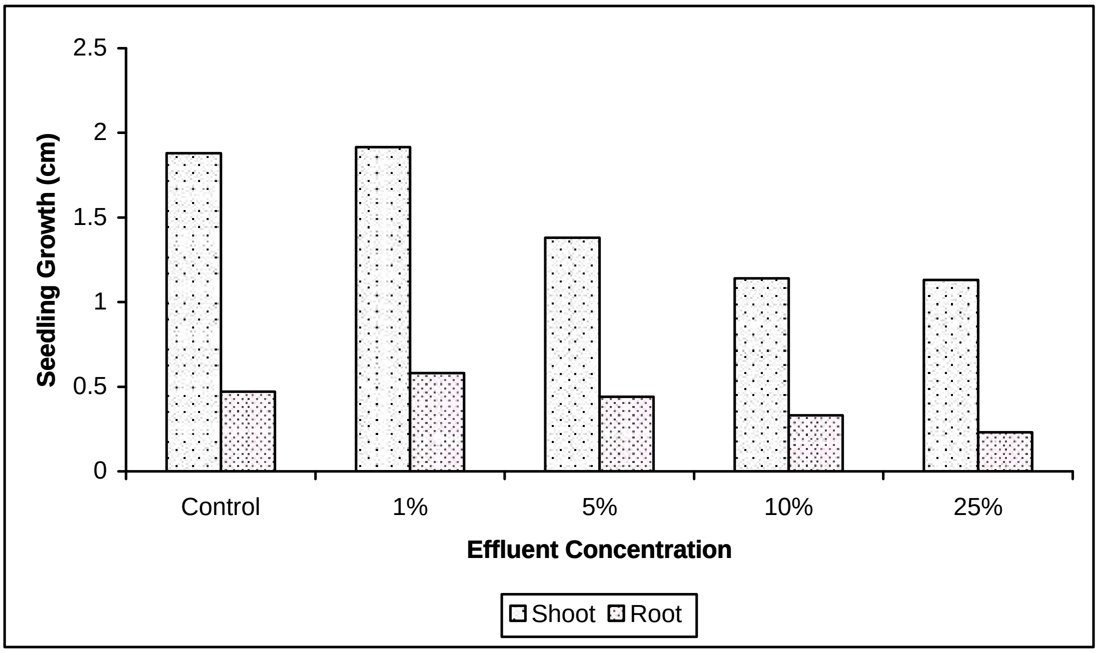


Fig. 6: Effect of effluent on seedling growth of *Triticum aestivum* variance ratio at 5% level, Fcal=23.23, 19.61(Ftab=4.76,5.14) and Fcal= 4.83, 6.06(Ftab=4.76,5.14) for days of sowing and treatment concentration at d.f.(3,6) (2,6) for shoots and roots respectively.

4.6 Relative Degree of Enhancement or Inhibition by Effluent on Seedling Growth

Figures 7 and 8 illustrate the relative degree of enhancement or inhibition by effluent on seedling growth of the test crops. The result showed that shoot growth was relatively enhanced by 1 percent and 5 percent of the effluent concentrations in case of shoot growth of rice where as in case of wheat, shoot growth was enhanced at 1 percent only. But, in all other cases the relative percentage of seedling growth was inhibited by effluent concentration as compared to the control. Maximum inhibition was 86.94 percent in 25 percent effluent concentration in case of root growth of rice.

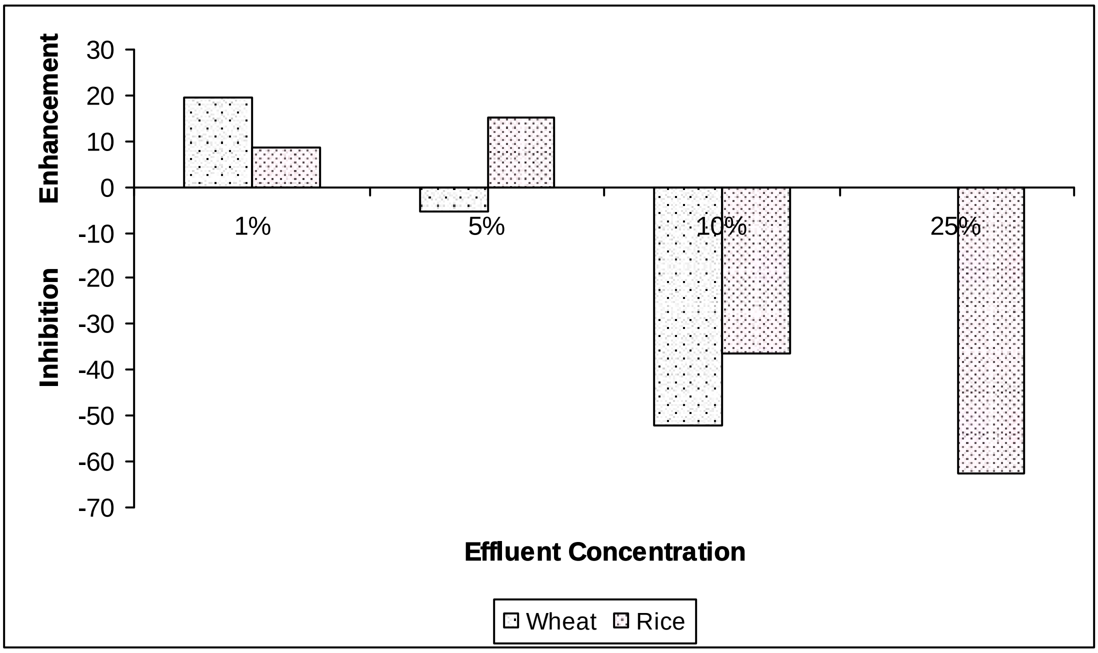


Fig. 7 Relative Degree of Enhancement/Inhibition on Shoot Growth by Effluent

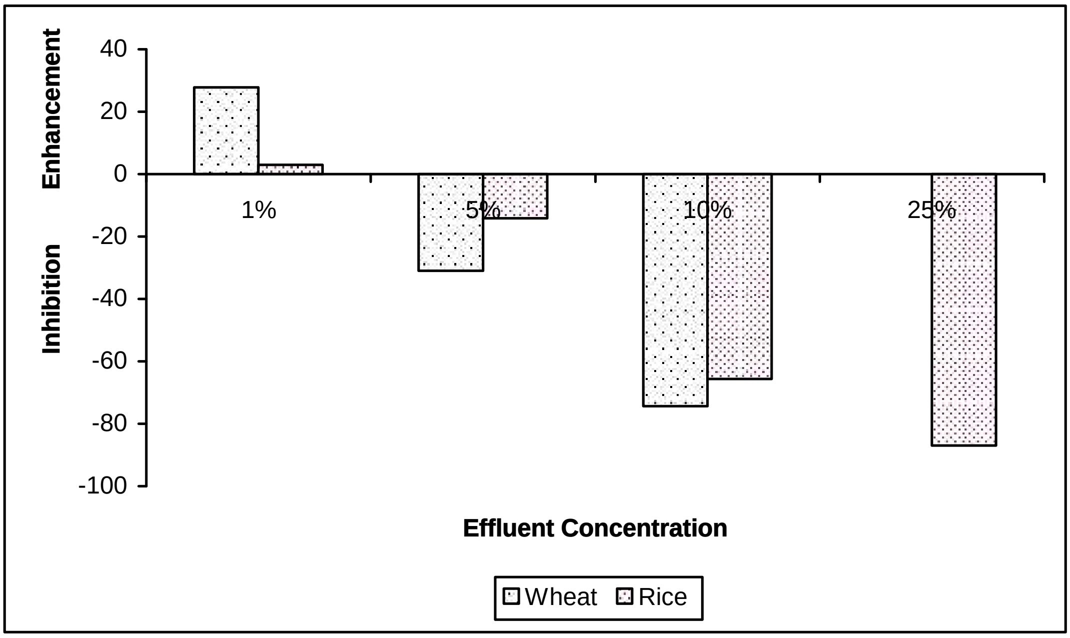


Fig. 8 Relative Degree of Enhancement/Inhibition on Root Growth by Effluent

4.7 Effect of Effluent on Seedling Weight

Effect of Effluent on Fresh Weight of Seedling

The effects of effluent on fresh weight of seedling of two test species are shown in figures 9 and 10. Generally lower concentrations of effluent (1% and

5%) enhanced the fresh weight of seedling in case of rice only. The enhancement was more at 1 percent and inhibition was more at 25 percent.

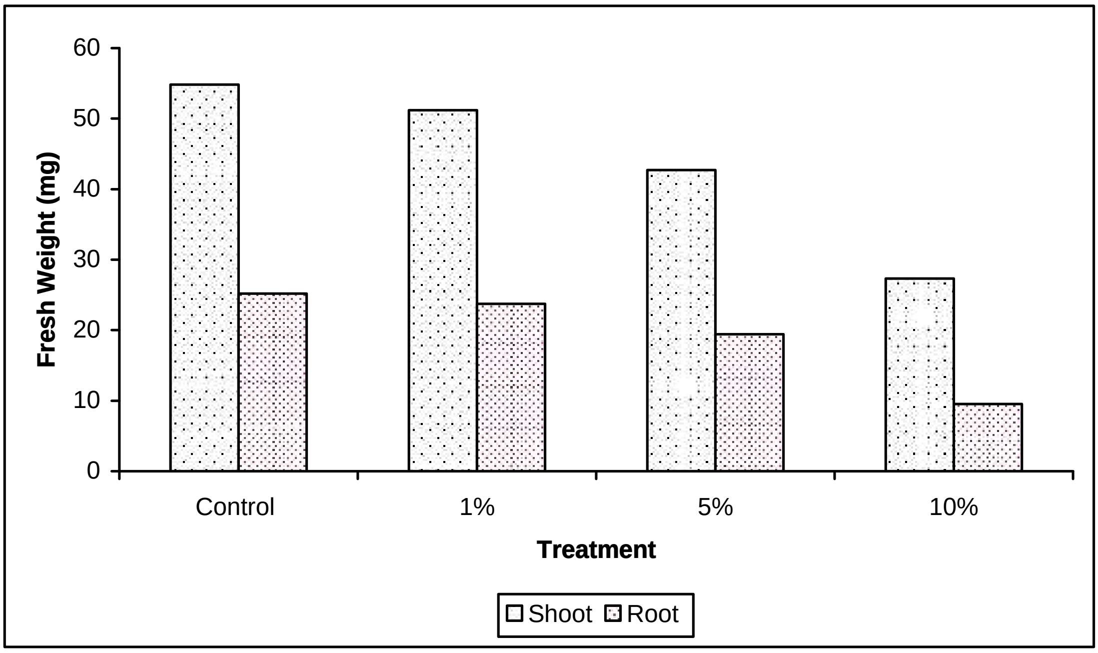


Fig.9: Effect of effluent on fresh weight of *Triticum aestivum* seedling, variance ratio at 5% level, Fcal= 7.74 (Ftab=5.99) at d.f. (1,6) for seedling weight with respect to effluent concentration.

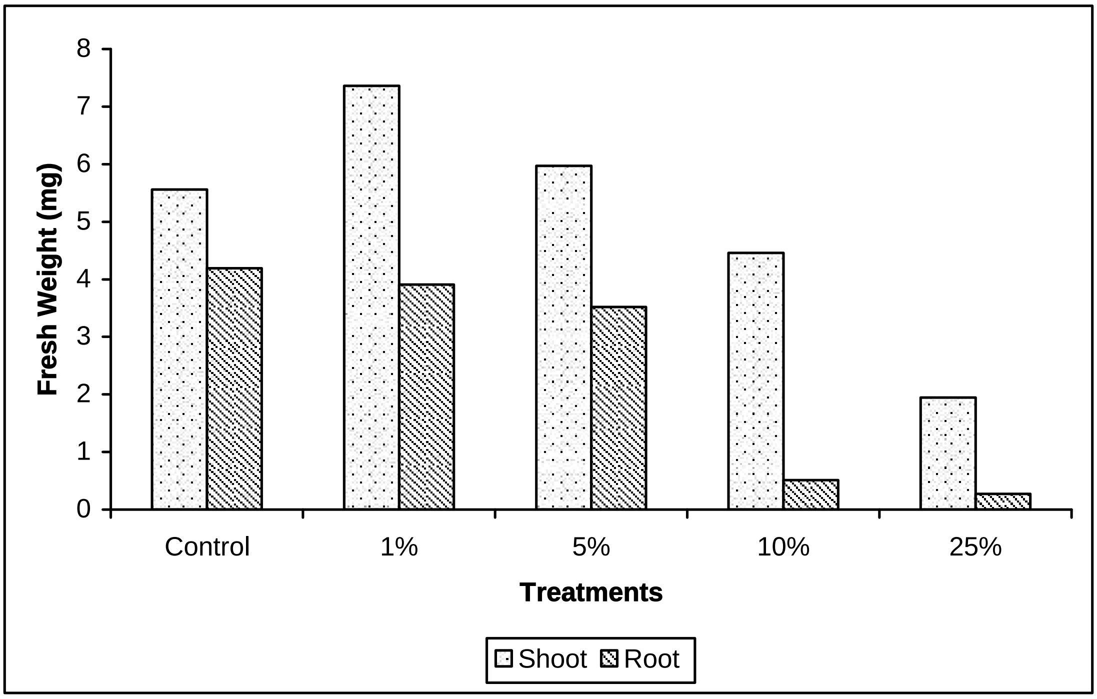


Fig 10: Effect of effluent on fresh weight of *Oryza sativa* seedling, variance ratio at 5% level, Fcal=12.03(Ftab=5.32) for seedling weight with respect to effluent concentration at d.f. (1, 8)

4.8 Evaluation of Relative Degree of Enhancement or Inhibition on Fresh Weight of seedling

Figures 11 and 12 illustrate the relative degree of enhancement or inhibition by effluent on fresh weight of shoots and roots of two test crops. Fresh weight of seedling (shoot) was relatively, enhanced by 1 percent and 5 percent in case of rice, while it was relatively inhibited in all other cases. The relative enhancement in shoot was found to be maximum (32.37%) by 1 percent effluent concentration in rice.

In case of root, there was slight inhibitions (5.75%) in wheat and (6.68%) in rice at 1 percent. Comparatively root of rice was fond more inhibited than other.

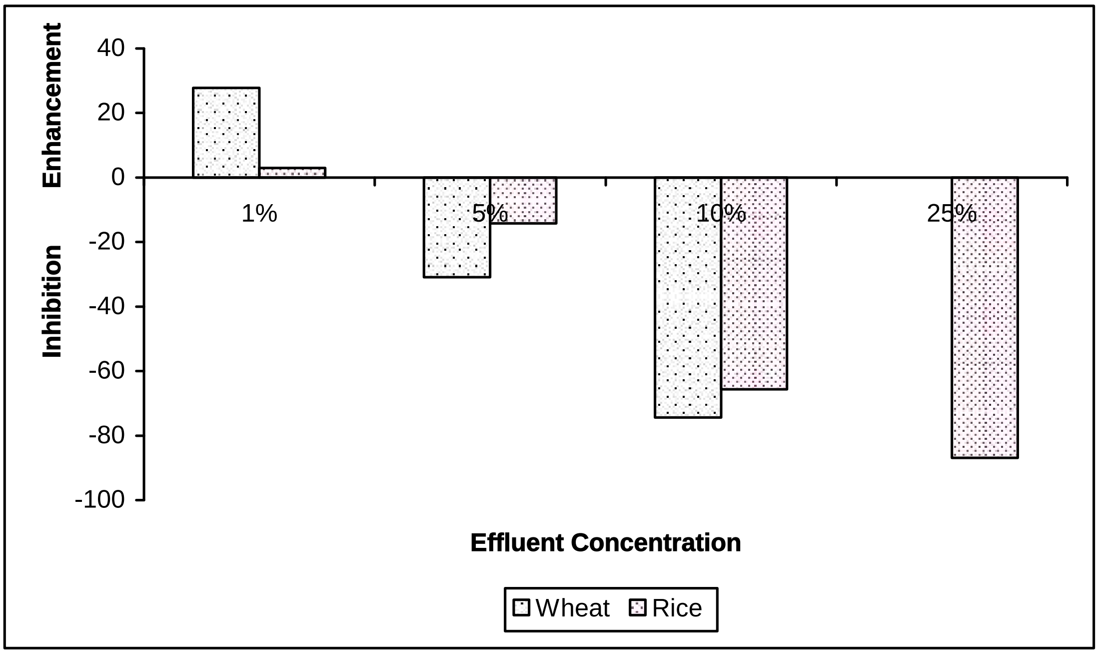


Fig. 11: Relative Degree of Enhancement/Inhibition on Fresh Weight of Shoot by Effluent

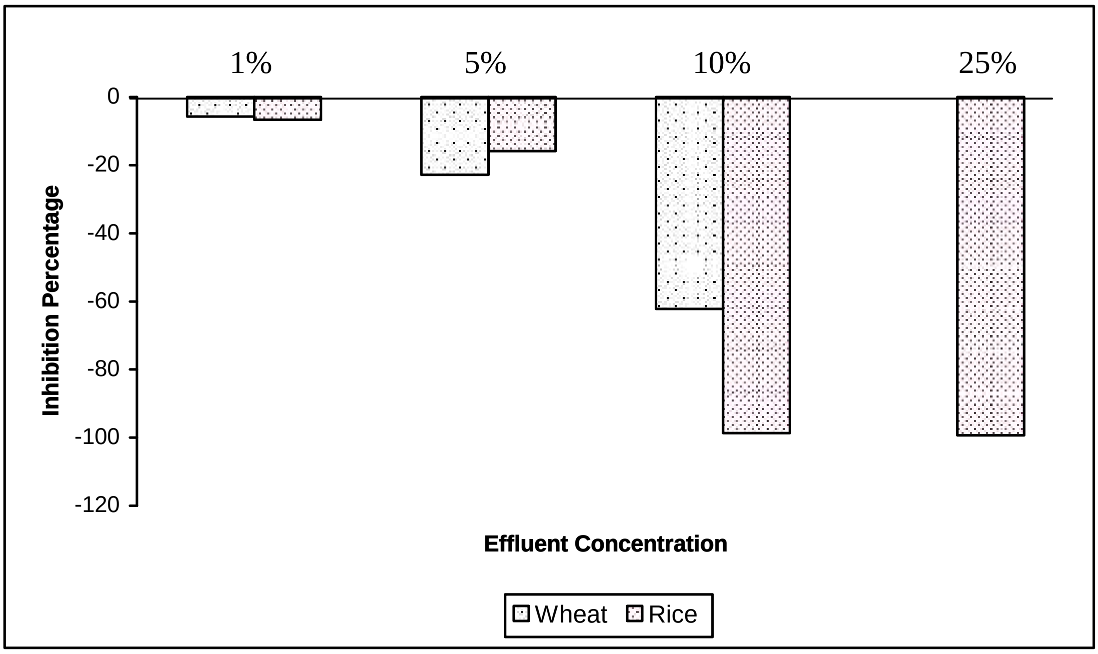


Fig12: Relative Degree of Inhibition on Fresh Weight of Root by Effluent

4.9 Effect of Effluent on Dry Weight of Seedling

Figures 13 and 14 illustrated the effect of different concentration of effluent on dry weight of shoot and root of test crops. The effect of concentration of effluent was found statistically significant at 5 % level. The dry weight of rice seedling decreased at higher concentration but comparatively it was higher in case of 1 percent and 5 percent effluent concentration where as in case of wheat, the dry weight has decreased with the increase of concentration except at 1 percent effluent concentration which slightly enhanced the dry weight of wheat seedling.

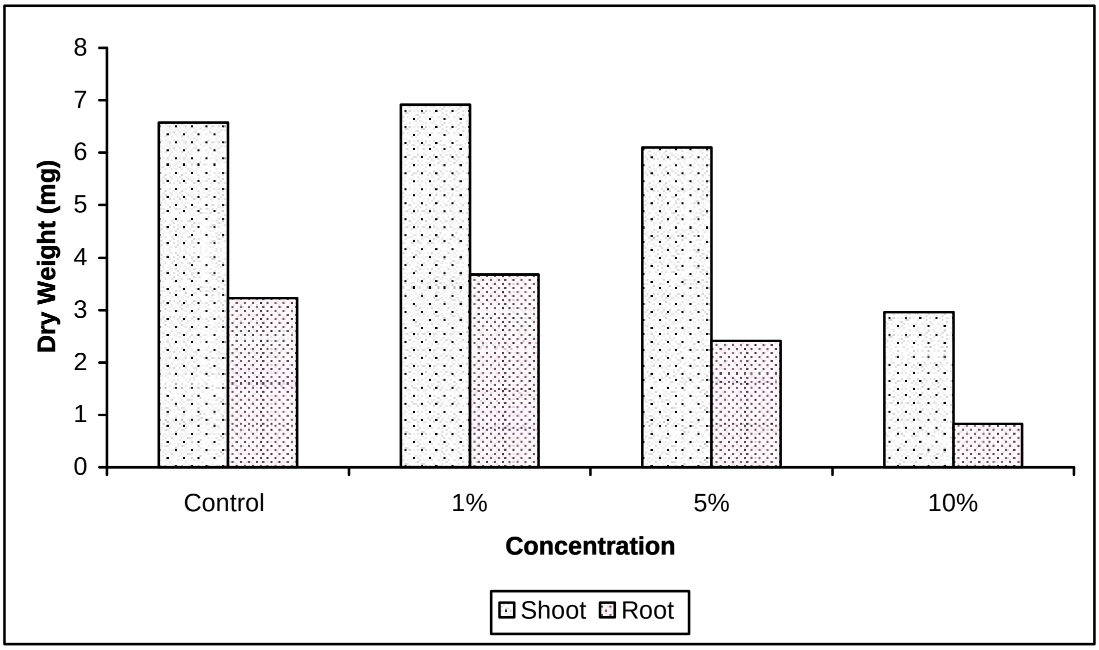


Fig.13: Affect of effluent on dry weight of *Triticum aestivum* seedling, variance ratio at 5% level, Fcal= 7.88(Ftab=5.99) at d.f.(1,6) for seedling weight with respect to effluent concentration.

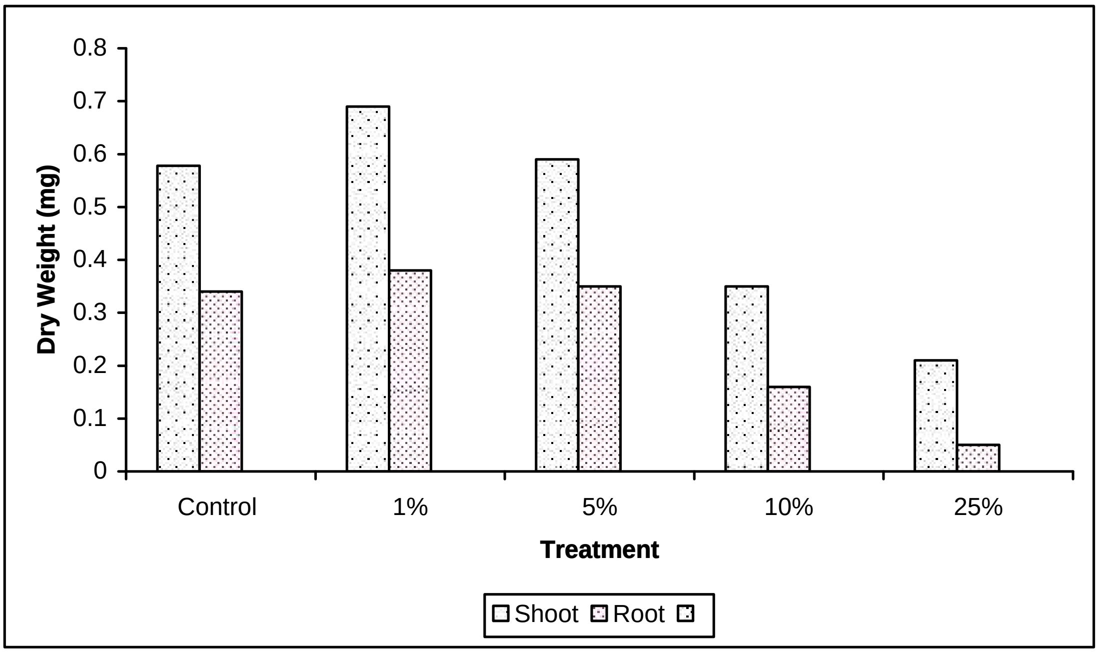


Fig.14: Effect of effluent on dry weight of *Oryza sativa* seedling. Variance ratio at 5% level, Fcal=4.34(Ftab=5.32) at d.f. (1,3) for seedling weight with respect to effluent concentration.

4.10 Evaluation of Relative Degree of Enhancement or Inhibition in Dry

Weight of Seedling

Figures 15 and16 showed the effect of effluent on dry weight of shoot and root seedling of two test crops. The relative value of dry weight was found to be decreased by 10 percent and 25 percent effluent concentrations in dry weight of rice seedlings where as in case of dry weight of wheat seedling, 5 percent effluent concentration was found to be slightly inhibitory. Contrary to this the relative dry weight of both rice and wheat seedlings enhanced by 1 percent effluent concentration. Maximum relative enhancement (19.37%) and inhibition (85.29%) was found in rice seedling by 1 percent and 25 percent effluent concentration respectively.

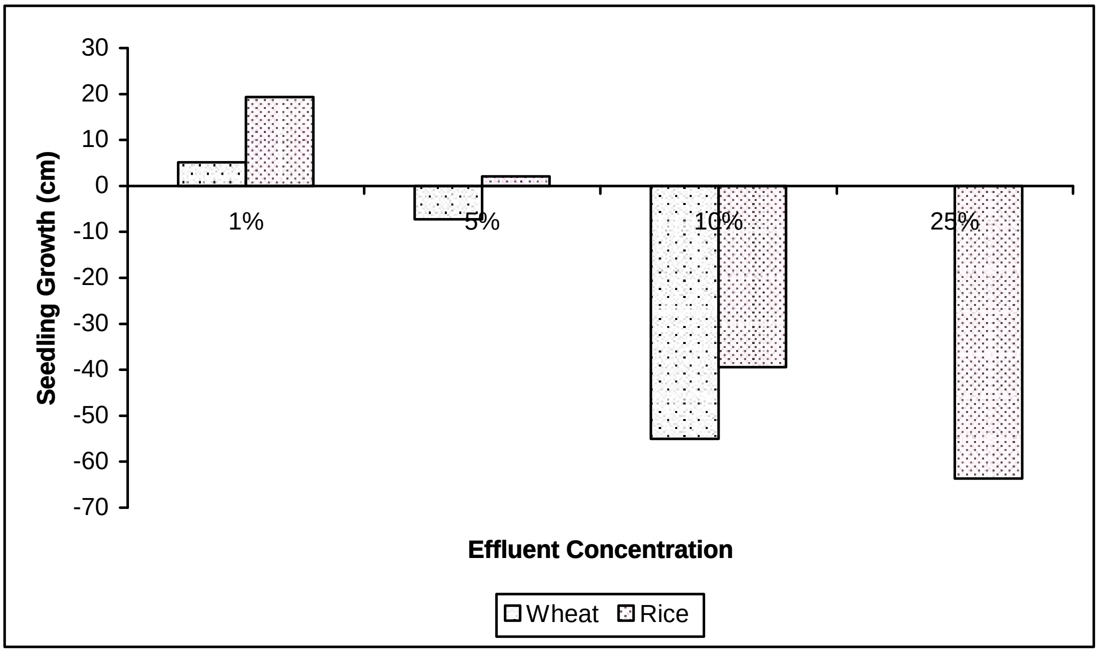


Fig. 15: Relative Degree of Enhancement/Inhibition on Dry Weight of Shoot by Effluent

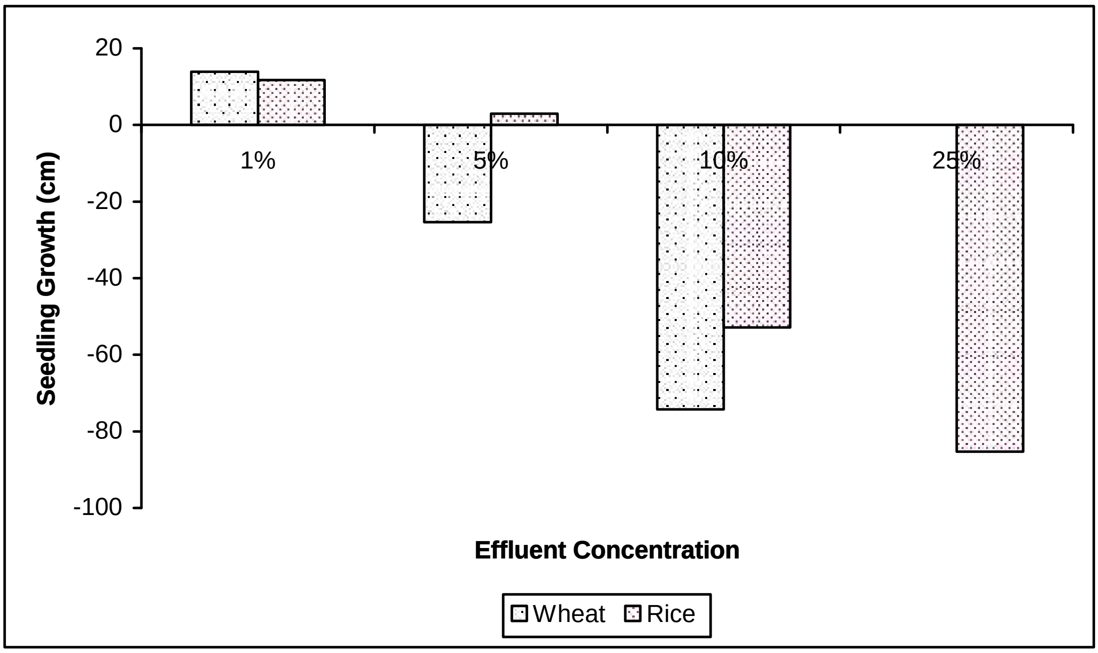


Fig.16: Relative Degree of Enhancement/Inhibition on Dry Weight of Root by Effluent

4.11 Interview with Local People

Local farmers of the study area were interviewed about the impact on the productivity of crops by the irrigation of effluent polluted water. All the details of approximate crop productivity of rice and wheat have been tabulated in the table 4.

The data obtained through interview with local people revealed that the average productivity of rice and wheat on the land irrigated with unpolluted stream water was found to be around 4,601 kg/ha and 837 kg/ha respectively where as on the land irrigated with effluent polluted water was found to be 2,477 kg/ha and 605 kg/ha respectively.

Table 4: Crop productivity in the study area as given by different respondents

S.N.	Crops	Site A			Site B		
		Yield in Kg	Land Area (hectare)	Yield in Kg/ha	Yield in Kg	Land Area (hectare)	Yield in Kg/ha
1.	Rice	4000	0.99	4040	1500	1.65	909
	Wheat	600	0.66	909	800	1.65	484
2.	Rice	8000	1.83	4371	1400	0.66	2121
	Wheat	1300	1.5	866	400	0.66	606
3.	Rice	1900	0.42	4523	1600	0.66	2424
	Wheat	400	0.42	952	500	0.66	757
4.	Rice	8500	1.65	5151	2400	1.65	1454
	Wheat	1300	1.42	915	600	1.12	535
5.	Rice	15000	2.97	5050	1300	0.49	2653
	Wheat	2100	2.97	707	300	0.33	909
6.	Rice	2000	0.66	3030	2000	0.5	4000
	Wheat	500	0.66	757	400	0.5	500
7.	Rice	8000	1.65	4848	1400	0.66	2121
	Wheat	1400	1.65	848	150	0.33	454
8.	Rice	5000	1.32	3787	1500	0.33	4545
	Wheat	1200	1.32	909	600	0.33	1500
9.	Rice	800	0.19	4210	1500	0.66	2272
	Wheat	150	0.19	789	600	0.66	800
10.	Rice	21000	3.3	7000	3000	1.32	2272
	Wheat	2300	3.2	718	1000	1.32	500

Note: Site A – Irrigated with unpolluted stream water.

Note: Site B – Irrigated with Effluent polluted stream water.

Average production: Site A -Rice = 4601kg/hca, Wheat =837kg/hac. **Site B** Rice = 2,477kg/hca, Wheat =605kg/hac

Comparatively it was observed that the production rate of both rice and wheat of the land irrigated with unpolluted stream water was 2719kg/ha in average where as that of the land irrigated with effluent polluted water was 1583kg/ha which showed 40% less production than the unpolluted cropland.

5. DISCUSSION

In the present study attempts have been made to analyze some physico-chemical parameters of the effluent from Karnali distillery and its effect on agriculture land, plant growth and development. Distillery effluent pollution has become a serious problem for the local people and farmers living near the distillery. The present study also attempt to identify environmental injustice to local people and farmers due to the factory effluent.

Industrial effluents discharged without proper treatment is the major contributors of land and water pollution. Industrial wastes generate a large amount of organic and inorganic matters as by-products which when disposed off in river system, leads to high BOD and consequent oxygen depletion in the river (Anonymous, 2000). Several studies have reported highly toxic effect of industrial effluent on the soil quality and crop productivity where as few studies have also illustrated the possibilities of using of industrial effluents of certain industries for irrigation purposes.

The temperature of the distillery effluent was recorded as 105°C on the spot which was relatively higher than that of dilute and unpolluted stream water which were analyzed as 36°C and 30°C, respectively. An increase in water temperature decreases the oxygen saturation percentage and at the same time accelerates the lowering of DO levels. An increase in temperature also increases the toxicity of some chemical pollutants (Rao, 1991). Neupane (2003) and Anonymous (1995) found the temperature of the distillery effluent of Lumbini sugar factory to be 102°C and that of Mahendra sugar factory to be 100°C respectively which were close to the present study.

In the present study the pH of the effluent was found highly acidic with pH value 3.7 and 4.4 in concentrate and dilute effluent, respectively. The pH recorded were very low than the tolerance limit fixed for any industrial effluent (NS, 1990) or any fermentation industry (NS, 1995), where as in unpolluted water it was slightly acidic. The pH value of any solution depends upon the concentration of hydrogen ion and is one of the indicators commonly used to find the level of pollution. Anonymous (1995) and Neupane (2003) found the pH in distillery effluents of sugar mills to be 4.7 and 4.3 respectively which were close to that of present study. Sah *et al*. (2000) found pH of Shree distillery to be 5.1 which was relatively higher or less acidic than in the present report. The low pH of the distillery effluent might be due to the presence of organic acids such as CH_3 COOH (Sah *et al.*, 2000).

The total suspended solid (TSS) of the concentrate and dilute effluent were found extremely higher than the maximum limit fixed for a fermentation industry (NS, 1995) or any industrial effluent (NS, 1990). The high amount of TSS in the effluent might be due to presence of high organic suspended solids. Sah *et al.* (2000) and Devkota (1997) analyzed the TSS of distillery effluents to be 13,100 mg/l and 11,230 mg/l respectively which were similar to that of present study, where as the TSS of unpolluted stream water was found to be less than tolerance limit of any industrial effluent.

The DO values of concentrate and dilute effluents in the present study were analyzed extremely low with the values of 0.36 mg/l and 2.9 mg/l respectively, where as it was little bit high in unpolluted water.

DO levels in natural and waste water depend on the physical, chemical, and biological activities prevailing in water bodies. Low DO might be due to presence of high amount of oxygen demanding organic wastes. Sah *et al.* (2000) analyzed the DO of Shree distillery effluent and found to be 0.87mg/l which was close to that of concentrate effluent of the present study, where as Anonymous (1989), Gewali *et al.* (1994) and Sharma and Rijal (1988) analyzed DO to be zero in carpet factory effluent, dying effluent and carpet factory effluent respectively.

Nitrogen content in concentrate and dilute effluent were found to be very high as compared to unpolluted stream water. Sahai *et al*. (1983) and Sah *et al*. (2000) analyzed the Nitrogen content of distillery effluents which were lower than that of present study. High amount of nitrogen content might be due to presence of high amount of Nitrogen rich organic materials. But still nitrogen content in concentrate effluent is very low than that of a typical Indian distillery range (Rajukkannu *et al.*, 1997).

Phosphorus content in the concentrate effluent was found to be 141.4 mg/l which was many folds higher than in dilute and unpolluted stream water. Sah *et al.* (2000) found the phosphorus content in concentrate distillery effluent to be 215 mg/l which was similar result to the present study.

Similarly, potassium content for concentrate and dilute effluents were found 5440 mg/l which was extremely higher than unpolluted water. Mahimairaja *et al*. (2004) reported that among the plant nutrients potassium was present in the highest amount in a distillery spent wash followed by Nitrogen and phosphorus. Similar result was found in the present study. Sah *et al*. (2000) analyzed the potassium content of Shree distillery to be 215 mg/l which was lower than that of present study.

The high amount of Nitrogen, Phosphorus, and Potassium in the distillery effluent indicated that the effluent was rich in major plant nutrients which could be utilized for irrigation after proper treatment.

The BOD values of concentrate and dilute effluents were found to be very high than the tolerance limit fixed for any fermentation industry (NS, 1995) or any industrial effluent (NS, 1990). The BOD value depends on micro-organism and oxidizable organic matter present in the effluent or the high value of BOD might be due to presence of high oxidizable organic matter. The range of BOD for a typical distillery effluent in India was 46100 mg/l to 96000 mg/l (Rajukkannu *et al*., 1997) which was close to that of present study. Sah *et al*. (2000) and Devkota (1997) determined the BOD of distillery effluents which were very high than the tolerance limit but less than that of present study.

Similarly, the COD of both concentrate and dilute effluent were observed very high than the tolerance limit fixed for industrial effluent (NS, 1990). The high COD might be due to untreated effluent of the distillery. Generally high COD of effluent is due to rapid consumption of dissolved and inorganic materials. Sah *et al*. (2000), Anonymous (1990), Gewali *et al*. (1994) and Neupane (2003) analyzed the COD of Shree distillery, carpet factory, dyeing effluent and distillery effluent respectively and found the similar results that of the present study. But still the COD of concentrate effluent in present study i.e 58400 mg/l was less than that in effluent of typical distillery in India i.e. 10400 mg/l–134400 mg/l (Rajukkannu *et al.,* 1997) where as the COD of unpolluted stream water was found to be 152 mg/l which was very low and within the tolerance limit.

Iron content in the concentrate and dilute effluents were found to be 115mg/l and 102.4 mg/l respectively. Which were many folds higher than the tolerance limit for industrial effluent (IS, 1974), where as in unpolluted stream water it was only 4.7 mg/l. Abnormal level of iron adversely affect the growth and causes other physiological disorder in rice and other crop plants (Woolhouse, 1983). Hence the high contents of iron revealed the toxicity of effluent for irrigation. Sah *et al*. (2000) and Ghimire (1994) analyzed the iron content in Shree distillery to be 57.05 mg/l and in steel industry to be 49 mg/l respectively which were higher than the tolerance limit but were lower than in the present study.

Manganese content in the concentrate and dilute effluent were analyzed to be higher than the tolerance limit for industrial effluent (IS, 1974) where as in unpolluted stream water it was found very low than tolerance limit. High content of Manganese in irrigating waste water inhibited the growth of root and hypocotyle in *Lactuca sativa* (Kummerova *et al*., 1989).

The values of Manganese in present study were found near to the range of Manganese content of typical distillery in India (4.6 - 2.1 mg/l) (Rajukannu *et al*., 1997). Sah *et al*. (2000) found the manganese to be 11.13 mg/l which was much higher than that of the present study.

Lead content in the concentrate and dilute effluent were found higher than the tolerance limit of the value 0.1 mg/L (NS, 1990), where as it was present in negligible amount in unpolluted stream water. High content of lead inhibits the root growth and seed germination of source vegetable crops (Pokhral *et al*., 2001). Sah *et al*. (2000) analyzed Pd content of Shree distilley effluent to be 0.28 mg/l which was similar to that of present study.

Copper content in concentrate and dilute effluents were analysed as 0.14 mg/l and 0.05 mg/l which were very low than the maximum permissible value of 3.0 mg/l (NS, 1990) where as in unpolluted water it was still lower with the value of 0.04 mg/l. The range of copper content in a distillery effluent was found to be 0.4–2.1 mg/l (Rajukkannu *et al*., 1997). Sah *et al*. (2000) analyzed the copper content of distillery effluent to be 4.63 mg/l which was very high than that of present study.

Zinc content in concentrate and dilute effluent as well as in unpolluted stream water were found to be less than the threshold value of 5.0 mg/l (NS, 1990) which showed that the uptake of N, P and K had not been affected by Zn (Kotake et al., 1981). Sah *et al*. (2000) and Rajukkannu *et al*. (1997) analysed Zn content of distillery effluent and found to be 2.4 mg/l and 3.4 mg/l respectively which were similar to that of present study.

Cadmium contents in concentrate and dilute effluent were analyzed as 7.5 mg/l an 5.8 mg/l respectively which were very high than the tolerance limit fixed for industrial effluent (NS, 1990). Higher concentration of cadmium inhibits uptake of Phosphorus and Potassium (Matsuo *et al.,* 1995) and reduced the plant growth (Lee *et al*., 1976).

To evaluate the suitability of effluent for irrigation it is also necessary to consider effects of its constituents on both plant and soil (Thorne and Peferson, 1949). The soil irrigated with effluent contaminated water was found slightly acidic with pH value 6.4 which was within the tolerable range for the soil (Sah *et al*., 2000) where as the soil irrigated with uncontaminated water was found to be slightly basic with pH value 7.2. Decrease in the pH of distillery effluent irrigated soil may be attributed to the acidic nature of the spent wash and the release of organic acids during the decomposition.

The total average organic matter content in the soil irrigated with effluent polluted water was found to be higher than the soil irrigated with unpolluted water. The high amount of organic matter in effluent irrigated soil might be due to the high organic nature of the effluent. Acharya (2001) and Neupane (2003) found the organic content in the soil irrigated with brewery industry effluent and sugar industry effluent to be higher than in the soil irrigated with uncontaminated water.

The average values of nitrogen, phosphorus and potassium in the soil irrigated with effluent polluted water were found to be higher than in the soil irrigated with unpolluted stream water. The high amount of N, P and K in the soil might be due to irrigation with N, P, and K rich distillery effluent. Neupane (2003) analyzed the N, P and K content in soil irrigated with sugar industry effluent to be 0.033 percent, 126 kg/ha and 191kg/ha respectively which were similar to that of in present study. Soil amendment with distillery effluent for wheat and rice cultivations increased organic carbon and available potassium content of post harvest soils (Pathak *et al*., 1999). Saliha (2003) found marked improvement in soil fertility with respect to N, P and K that was irrigated with distillery spent wash.

Except Zn, the concentration of heavy metals Fe, Mn, Cu, Pb and Cd were found higher amount in the soil irrigated with effluent polluted water than in the soil irrigated with unpolluted water. Sah et al. (2000) found the concentration of micronutrients (Zn, Fe, Mn and Cu) increased in the soil irrigated with paper industry effluent.

Though the major nutrients like N, P and K have increased in the soil by distillery effluent irrigation, at the same time heavy metals were found increased, the excess amount of which may decrease the soil fertility. Effluent from certain industries such as distilleries, breweries, sugar mill and dairies were widely used to irrigate agricultural field (Tauro, 1988; Hoddy, 1991; Sammy *et al*., 1995; Anonymous, 2000).

These effluents are rich in essential plant nutrients and organic matters, but sometimes have high concentration of Zn, Cu, Cd and Pb (Acharya, 2001).Untreated effluent from paper factory are reported as disadvantageous due to formation of impenetrable mat like fibre depositions on the ground (Scafield, 1940). The present study also revealed the same result. Many studies have suggested the requirement of effluent treatment before their use in irrigation or industrial purpose (Jha and Niroula, 1998; Sahai *et al*., 1983; Goswami and Naik, 1991; Mukharjee and Nelliyal, 2006).

The texture of soil irrigated with effluent contaminated water was found to be sandy loam before monsoon but after monsoon, the texture of same soil changed into silty loam. It might be due to the surface run off during the rainfall. Besides these, during the monsoon season, the soil was not irrigated where as before monsoon soil was irrigated with effluent polluted stream water, which added sand particles of stream along with water.

The average annual production was found higher in case of crop field irrigated with unpolluted water. The effluent might have decreased the productivity of the soil. Farmers had also complained about the rapid growth of unnecessary weeds and insects in the crop field which decrease the productivity.

In the present investigation attempts have been made to assess the effect of distillery effluent on seed germination and seedling growth of two test crops (rice and wheat). The degree of effect was found to be varied according to treatment as well as the test species and parameters tested.

The effluent showed inhibitory effect on the two test crops in most of the cases, where as in few cases it was stimulatory in comparison to control. The germination of test seeds was observed to be similar to control in lower concentrations (1% for wheat and 1%, 5% for rice). But in higher concentration (10% for wheat and 25% for rice) germination was completely inhibited. Similar result was found by Sahai *et al.* (1983) in case of rice (*Oryza sativa*). The inhibition effect of the germinations was more prominent on the seed of wheat (*Triticum aestivum*) than in rice (*Oryza sativa*) which showed that the effect of distillery effluent was crop specific. This result was supported by Ramana *et al*. (2002).

Extreme range of pH value might be the main reason for the greater toxic effect on the seed germination, at higher concentration. This was supported by the report of Chaudhary (1983) and Thukural and Kaur (1987).

The effluent had both stimulatory and inhibitory effects on growth of seedlings as compared to control. In case of rice (*Oryza sativa*) it showed stimulatory effect at lower concentrations (1% and 5%) but inhibitory effect was found at higher concentration (25%) where as in case of wheat, it had inhibitory effect at all concentration (except 1%) as compared to control. Chandra *et al.* (2004) analyzed effect of distillery effect on the growth of *Phaseolus aureus* and found stimulatory effect at lower concentration (1%-5%) and inhibitory effect (15%-20%) which was similar to that in present study.

Plant absorbs various heavy metals as micronutrients for their growth and development (Sarangi *et al*., 1993). However, above an optimum concentration they may cause various disturbances to plant system (Martin and Cughery, 1982). The inhibition in normal growth at higher concentration might be due to effect of heavy metals. Breeze (1973) had also reported that excess concentrations from industrial pollutants could have adverse effects. Patel and Kumar (1991) reported that industrial effluent at and above 20 percent concentration induced a gradual decrease in the germination percentage and seedling growth of *Brassica juncea* L.

Ghimire (1994), Thapa (1994), and Shakya (1998) reported the effect of heavy metals like Cr, Pb, and Zn etc. on germination and found inhibition and enhancement effects in different concentration which was similar to present study.

In the present study root growth of both test crops were found more affected than shoot growth. Sahai *et al*. (1983) reported that distillery effluent contained excessive amount of dissolved materials (cations and anions) which might be injurious to germination and seedling growth and also observed that root growth was more adversely affected than shoot growth which supported the result of present study. The effect of heavy metals on growth parameters may be attributed to the result of studies carried out by Silwal (1999), Kharel (1999), and Sharma (2000).

Seedling growth of plant is directly related with water uptake and fresh weight of the seedling. If there is more growth, correspondingly there may be more water uptake which yields more fresh weight of the seedling. The availability of metallic micro nutrients serves as co-factors and activators in enzyme reaction by forming metal enzyme complex (Mildvan, 1970). In the present study, it was observed that at lower concentrations (1% and 5% in case of rice) the seedling growth was stimulated according to which fresh weight of seedlings was also found more in these treatments. But in case of wheat, seedling growth and fresh weight of seedlings decreased with the increase of concentrations. Analysis of relative degree of enhancement or inhibition showed various degree of sensitivity differing at treatment concentration and test crops.

Fresh weight enhancement in case of rice was observed at 1 percent and 5 percent with the values of 32.37 percent and 7.37 percent respectively but at 10 percent and 25 percent the marked inhibition was observed. Where as in case of wheat (*Triticum aestivum*) inhibitions of fresh weight was found in all concentrations. The maximum inhibition was observed at 25 percent in case of rice with the value of 65 percent. Enhancement at lower concentration might be due to stimulation of auxin regulated cell elongation. This was supported by the results of micro and macro element induced in enhancement of seedling growth at lower concentration obtained by Agrawal *et al*. (1961).

But in case of *Triticum aestivum* fresh weight was inhibited in all effluent concentrations and no germinations was obtained at 25 percent. Relative enhancement was totally absent in case of fresh weight of root of both the test crops. Maximum inhibition of root was found as 99.3 percent at 25 percent in case of rice. Low pH value of the effluent may be the main cause for the greater effect of seeding growth. It gets support from Thukural and Kaur (1987).

In case of dry weight of two test crops, different trends were observed. The dry weight of shoot and root was increased at 1 and 5 percent in case of rice and at 1 percent in case of wheat. The highest enhancement of shoot was found in rice by 19.37 percent at 1 percent effluent, where as it was 5.16 percent for wheat. Similar result was found in roots but the percentage of enhancement was greater than shoot in case of wheat at 1 percent and for rice at 5 percent.

Such types of irregular effect of effluents on fresh and dry weight of seedling might be due to lack of enough mobilization of reserved food to the seedling . The reserved food materials stored in cotyledons were not mobilized in the case where the growth was inhibited and increased dry weight of shoot where as it was mobilized to root and decreased the dry weight of shoot in the case where growth was enhanced. Similar result of increase or decrease of dry weight in case of different Brassica crops was obtained by Pokhrel (2000) and Sharma (2000) with the treatment of different concentration of Pb and Cr.

5.1 Environmental Justice

Karnali distillery is located near the human settlements and large agriculture land where majority people from local community have sole occupation of crop farming. Since more than twenty years the factory has been frequently discharging its effluent in the Kiran khola near by the factory which is a main source of irrigations for marginalized local farmers.

Environmental protection Act 1996 has made the mandatory provisions to carryout Environment Impact Assessment (EIA), prior to carry out establishing industries that may cause adverse impact on environment but Karnali distillery has no report of EIA. Anonymous (1991) mentioned the trend of establishing industry in Nepal without considering management of pollution and control of adverse impact on the local environment of industrial area. Present study revealed that BOD, COD and TSS of discharged effluent were extremely higher than tolerance limit (NS, 1990). Likewise some heavy metals (Pb, Cd, Fe) and pH were also found very abnormal. It has resulted in environmental hazards and decreased the cropland productivity which has become serious issue of environmental injustice to local farmers.

Local farmers have been experiencing negative effect in their cropland productivity due to the irrigation of effluent mixed polluted water. Annually the farmers have to bear about 40 percent loss in crop productivity. The present study also showed increased fertility of soil in term of Phosphorus and

Potassium but at the same time amount of heavy metals has also increased. The over dosage of Phosphorus, Potassium and heavy metals may interfere the normal growth of the crop plants that ultimately decrease the yield. Thus this study verified the experience of the local farmers on the trend of decrease in productivity by interfering fertility of soil. This result was found similar to Juwarkar *et al*. (1990), Mahimaraja *et al*. (2006) and Nagraj *et al*. (2006). The national daily newspaper Anonymous (1^{st} July, 2006) from Nepalgunj also reported that cropland of four VDCs i.e Khajura Khurd, Bageshwari, Sitapur and Radhapur have decreased the productivity due to the effect of Karnali distillery effluent and farmers are getting trouble in their occupation which revealed existence of environmental injustice.

Local farmers do not prefer to use effluent mixed water in their seed beds of rice and wheat because they found adverse effect of the effluent in the seed germination. In the present study, seed germination test and statistical analysis also strongly supported the farmers' experience of significant negative effect in rice and wheat seed germination. Sahai *et al*. (1983) and Tomer *et al*. (2002) found the inhibitory effect of distillery effluents in the seed germination of *Oryza sativa* and *Helianthus annus* respectively.

Local farmer have also been facing the problems of abortion and death of their cattle due to the consumption of effluent mixed water. Similarly hazardous awful smell of the effluent in the adjoining area of the industry has been noticed as other issues of environmental injustice caused by Karnali distillery industry.

From this study it was also found that farmers of low income and socially discriminated groups who can not afford other alternative irrigation sources rather than effluent mixed water are the victims of environmental injustice. The case is similar to the statement of Ghimire (2003) which stated that environmental degradation and pollution produce more impact on poor than rich people. Since poor people are usually exposed directly to such hazards and unable to manage protections measures due to lack of resources.

Local farmers from the study area are poor and uneducated. They have lack of awareness and no clear guidelines to get the compensations. There is no official report in cottage and small industry board against the factory (Anonymous, 2006) but local people have complained to owner of the factory for the compensation on their loss. There is no liability from factory owner for the concerned deprived farmers. This seems to violating the principle of environmental justice where it has been clearly mentioned that environmental justice protects the rights of victims of environmental injustice to receive full compensation and reparation for damage as well as quality health care.

Although no effective protest has been made by local people against the adverse environmental impact due to industry but the people have been raising voices for the search of proper management of industrial waste born pollutants. The factory owner seems silent to address the voices of the local farmers and not initiating to establish an effluent treatment plant. They have made temporary measures due to the people's pressure to collect effluent in reservoirs for certain period. This measure cannot solve the dispute between local people and factory owner. It clearly shows that factory owner is not serious for the proper management of effluent and its environmental hazards to provide environmental justice to local people. On the other hand local government, concerned organization have taken no effective initiation for the active enforcement of EPA/EPR and other existing legislation to ensure rights of environmental justice to local people. The information collected from the interview with factory manager revealed that in spite of realizing the necessity of effluent treatment, the factory owner is not willing to install the effluent treatment plant because of its high cost.

To minimize the existing injustice to the local farmers, the factory owner has to seek some alternative measures to treat or minimize the load of pollutants in the effluent before it is discharged to the river.

6. CONCLUSION AND RECOMMENDATIONS

The Physico-chemical characteristics such as temperature, pH, total suspended solids, DO, N, P, K, BOD and COD along with some important heavy metals of the effluent discharged by the Karnali Distillery Pvt. Ltd. and its impact on soil, seed germination, seedling growth, fresh and dry weight of two test crops viz. *Oryza sativa* and *Triticum aestivum* were analyzed. This investigation also included the issues of environmental injustice in the study area due to effluent pollution.

The study revealed that the concentrate distillery effluent was acidic with high content of BOD, COD, N, P, K and organic matter. Similarly except Zn and Cu no large difference were found in heavy metals such as Fe, Mn, Pb and Cd between concentrate and dilute effluent but appreciable variation was seen in between effluent free stream water and dilute effluent.

In case of soil analysis parameters such as N, P, K, organic matter and heavy metals (Fe, Mu, Cu, Pb, Cd) were found higher in the land irrigated with effluent polluted water than that of the land irrigated with unpolluted water.

Germination experiment of the test crops (*Oryza sativa* and *Triticum aestivum*) showed statistically significant inhibition effect at all the concentration. However, in case of rice (*Oryza sativa*) the percentage of germination at lower concentration (1% and 5%) reached up to the level of control at late hours (after96 hrs) of sowing. But in case of wheat (*Triticum aestivum*), all the concentration showed inhibitory effect at late hours (after96 hrs).

The seedling growth at lower concentration (1%, 5% in rice and 1% in wheat) was enhanced where as root growth was enhanced at 1 percent in both the test crops. Maximum inhibition was found in rice at 25 percent effluent concentration. The trend of enhancement or inhibition in case of fresh weight and dry weight was found irregular in case of wheat at 1 percent and in case of rice at 1 and 5 percent in root.

Based on interview with local farmers it was found that there was a gradual decrease (around 40 %) in the crop yield in the land irrigated with effluent mixed water and this showed negative effect in the soil productivity though the soil analysis showed increase in N, P, K and other soil nutrients. The local farmers also have to bear the death and abortion of their cattle due to consumption of effluent mixed stream water.

Local farmers were seeking for healthy and clean environment and compensation for their loss but factory owner does not seem serious for management of untreated waste or effluent discharged from the factory and compensation of the loss. On other hands people of the study area do not have clear idea about existing rules and regulation to get compensation and environmental justice. At the same time local government and other organization are found inactive to implement existing legislation.

The findings of this study concluded that local people and farmers are facing injustice in term of agricultural production, compensation and environmental hazards due to Karnali Distillery industry.

RECOMMENDATIONS

1. The distillery should properly treat its effluent by establishing effective effluent treatment plant or by adding some chemicals like nitrate to minimize malodour of the effluent before discharging it into the stream. The effluent also can be used as a good fertilizer after the proper management.

2. The use of undiluted effluent for irrigating seed beds at the time of germination should be strongly discouraged.

3. Awareness programme should be launched to the local farmers about the impact of effluent its proper utilization and environmental justice. The local government should take initiation for resolving conflict between local farmers and factory owner.

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Appendix I

Seed germination of test crops in percentage

Concentration	*Oryza sativa*					*Triticum asestivum*				
	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs	24 hrs	48 hrs	72 hrs	96 hrs	120 hrs
Control	88	98	100	100	100	86	93	100	100	100
1%	77	88	96	100	100	82	89	90	93	93
5%	54	60	89	97	98	65	68	78	80	80
10%	38	44	74	93	93	46	56	58	59	59
25%	-	14	43	45	46	-	-	-	-	-

Appendix II

Root and shoot length of *Oryza sativa* in average

Treatments	After 5 days (cm)		After 10 days (cm)		After 15 days (cm)	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	1.88	0.47	2.90	1.75	4.17	2.68
1%	1.91	0.58	3.04	1.39	4.53	2.76
5%	1.38	0.44	3.23	1.1	4.8	2.3
10%	1.14	0.33	2.39	0.45	2.66	0.92
25%	1.13	0.23	1.4	0.29	1.56	0.35

Appendix III

Root and shoot length of *Triticum aestivum* in average

Treatments	After 5 days (cm)		After 10 days (cm)		After 15 days (cm)	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	2.35	0.79	3.66	1.63	5.13	2.83
1%	2.27	0.57	3.58	1.51	6.14	3.62
5%	1.67	0.46	2.69	1.05	4.87	1.96

10%	1.41	0.39	20.42	1.64	2.45	0.72

Appendix IV

Fresh and dry weight of wheat seedlings (*Triticum aestivum*) in average

Treatments	Fresh Weight (mg)		Dry Weight (mg)	
	Shoot	Root	Shoot	Root
Control	54.83	25.19	6.58	3.23
1%	51.19	23.74	6.92	3.68
5%	42.7	19.44	6.1	2.41
10%	27.31	9.52	2.96	0.83

Appendix V

Fresh and dry weight of rice seedlings (*Oryza sativa*) in average

Treatments	Fresh Weight (mg)		Dry Weight (mg)	
	Shoot	Root	Shoot	Root
Control	5.56	4.19	0.57	0.34
1%	7.36	3.91	0.69	0.38
5%	5.97	3.52	0.59	0.35
10%	4.46	0.51	0.35	0.16
25%	1.94	0.27	0.21	0.05

Appendix VI

Proposed tolerance limited for industrial effluent discharged into inland surface waters in Nepal

Characteristics	Unit	Tolerance Limit
Temperature	°C	Shall not exceed 40°C
pH	-	5.5-9.0
Total suspended solids	mg/l	30-200
BOD at 20°C	mg/l	30-100
Oil and grease. Max	mg/l	10
Phenolic compounds. Max	mg/l	1.0
Cyandides (as Cn). Max	mg/l	0.2
Sulphides (as S). Max	mg/l	0.2
Radioactive Materials: i) Alpha emitters. Max ii) Beta emitters. Max	 c/ml c/ml	 10^{-7} 10^{-8}
Total residual chlorine	mg/l	1.0
Fluorides (as F). Max	mg/l	2.0
Arsenic (as As). Max	mg/l	0.2
Cadmium (as Cd). Max	mg/l	2.0
Hexavalent chromium (as Cr). Max	mg/l	0.1
Copper (as Cu). Max	mg/l	3.0
Lead (as pb). Max	mg/l	0.1
Mercury (as Hg). Max	mg/l	0.01
Nickel (as Ni). Max	mg/l	3.0
Selenium (as Se). Max	mg/l	0.05
Zinc (as Zn). Max	mg/l	5.0
Ammoniacal nitrogen. Max	mg/l	50
Chemical oxygen demand. Max	mg/l	250
Silver. Max	mg/l	0.1

Source: HMG, Nepal Bureau Standards and Measures (NBSM)

Appendix VII

Questionnaire used for household survey

Name of the VDC ……………………	Word No./Tole ………………………
Name of the respondent ………………	Age …………………
Sex …………..	Occupation ……………………..

1.	Which water resource do you use to irrigate your field?
2.	How long have you been using the polluted river water?
3.	How much crop field do you have?
4.	Which crops do you generally grow in your field?
5.	In which month do you irrigate your field?
6.	How much is your annual production?
7.	How many family members do you have?
8.	Is there any alternative source of income besides farming?
9.	Do you put fertilizer in your field? If yes, which type of fertilizer do you use usually?
10.	Have you ever got your field's soil checked?

Questionnaire used for analyzing environmental justice

1.	What do you know about environmental justice?
2.	Does the effluent from the factory pollute the river water? If Yes how?
3.	What kind of effect do you get in your crops due to irrigation polluted river water?
4.	Does the factory treat its effluent before discharging it?
5.	What kind of difference have you got in your annual crop production before and after t he establishment of the factory?
6.	How much loss do you get annually due to the irrigation of effluent polluted river water?
7.	Has the factory owner ever compensated the loss that you have to bear due to factory effluent?
8.	Have you ever tried to ask for the compensation with factory owner?
9.	Has the local government played any role to over come this problem of effluent pollution?
10.	Have you got any idea about the rules and regulation regarding disposal of effluent?
11.	What other kinds of loss do you have to bear due to the factory effluent besides in crop production?
12.	Is your local environment being polluted due to the factory effluent?

Questionnaire used for collecting general information about the factory

Location of the Factory			
a.	VDC/Municipality …………………	b.	Ward No………………
c.	Tole ………………………….		

Respondent			
a.	Name …………………	b.	Sex.………………
c.	Age ………………………….	d.	Designation in the factory ……...

1.	When was the factory established?
2.	How much is the daily/ annual production of the distillery?
3.	How much water is consumed daily by the factory?
4.	How much effluent is discharged daily?
5.	Do you treat the effluent before discharging it?
6.	Where and how do you discharge the effluent?
7.	How big is the reservoir to collect the effluent?
8.	How long do you collect the effluent in the reservoirs?
9.	In which months do you collect and release the effluent?
10.	Does the discharged effluent mix with any water resources?
11.	Do you know the standard of distillery effluent for safe environmental disposal?
12.	Do you have any idea of environmental law and regulation?

Appendix VIII

Principles of environmental justice

Preamble

WE THE PEOPLE OF COLOR, gathered together at this multinational People of Color Environment Leadership Summit, to begin to build a national and international movements of all peoples of color to fight the destruction and taking of our lands and communities, do hereby re-establish our spiritual interdependence to the sacredness of our Mother Earth; to respect and celebrate each of our cultures, languages and believes about the natural world and our roles in healing ourselves; to insure environmental justice; to promote economic alternatives which would contribute to devolvement of environmentally safe livelihoods; and , to secure our political, economic and cultural liberation that has been denied for over 500 years of colonization and oppression, resulting in the poisoning of our communities and land and the genocide of our people, do affirms and adopt these Principle of Environmental Justice:

1. Environmental justice affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.
2. Environmental justice demands the public policy be based on mutual respect and justice for all peoples, free from any forms of discriminations or bias.
3. Environmental justice mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of sustainable planet for humans and other living things.
4. Environmental justice calls for universal protection from nuclear testing, extraction, production and disposal of toxic/hazardous wastes and poisons and nuclear testing that threaten the fundamental right to clean air, land, water and food.
5. Environmental justice affirms the fundamental right to political, economic, cultural and environmental self-determination of all peoples.
6. Environmental justice demands the cessation of the production of all toxins, hazardous wastes and radioactive materials and that all past and current producers be held strictly accountable to the people for detoxification and containment at the point of production.
7. Environmental justice demands the right to participate as equal partners at every level of decision making including needs, assessment, planning, implementation, enforcement and evaluation.
8. Environmental justice affirms the right of all workers to a safe and healthy work environment, without being forced to choose between an unsafe livelihood and unemployment. It also affirms the right of those who works at home to be free from environmental hazards,
9. Environmental justice protects the right of victims of environmental injustice to receive full compensation and reparation for damages as well as quality health care.
10. Environmental justice considers governmental acts of environmental injustice a violation of international law, the Universal Declaration on Human Rights and the United Nations Convention on Genocide.
11. Environmental justice must recognize a special legal and natural relationship of Native Peoples to the U.S. government through treaties, agreements, compacts and covenants affirming sovereignty and self-determination.
12. Environmental justice affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with natural, honoring the cultural integrity of all our communities, and providing fair access for all to the full range of resources.
13. Environmental justice calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.
14. Environmental justice opposes the destructive operations of multi-national corporations.
15. Environmental justice opposes military occupation, repression and lands, people and cultures, and other life forms.
16. Environmental justice calls for the education of present and future generations which emphasizes social and environmental issues based on our experience and an appreciation of our diverse cultural respective.
17. Environmental justice requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little wastes as possible and make the conscious decision to challenge and reprioritize our lifestyles to ensure the health of the world for present and future generations.

Source: NBEJN2002

Plate 1: Entrance gate of Karnali distillery Pvt. Ltd.


Plate 2: Distillery effluent flowing through a canal from the factory


Plate 3: Distillery effluent mixing with stream water

Plate 4: Researcher taking interview with local farmer

Plate 5: Researcher working in the laboratory

Plate 6: Seed germination experiment

Plate 7: Paddy field irrigated with unpolluted stream water

Plate 8: Paddy field irrigated with effluent polluted stream water