EFFECTS OF DISTILLERY EFFLUENT ON SOME AGRICULTURAL CROPS: A CASE OF ENVIRONMENTAL INJUSTICE TO LOCAL FARMERS IN KHAJURA VDC, BANKE

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Abstract: Effluent discharged from the Karnali distillery Pvt. Ltd was analyzed to measure its effect on agricultural crops and environmental justice to the concerned people. Physico-chemical parameters like pH, temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Particles (TSS), Nitrogen (N), Phosphorus (P), Potassium (K) and some heavy metals such as Iron (Fe), Manganese (Mn), Cadmium (Cd), Lead (Pb), Zinc (Zn), and Copper (Cu) were analyzed and found most of the physico-chemical parameters were above the toxic level set by Nepal Bureau Standard. The analysis of physico-chemical parameters of the soil irrigated with effluent polluted water revealed appreciable increase in the soil nutrients (Organic Matter, N, P, K) along with the increase of toxic heavy metals such as Fe, Cd, Mn and Pb in the soil which has decreased annual crop productivity by around 40 percent. Similarly the effect of the effluent on seed germination, seedling growth, fresh weight and dry weight of seedlings of two test crops (*Oryza sativa* and *Triticum aestivum*) were also analyzed and found the effect varied in different concentration of treatment. Higher concentrations (10%, 25%) were found completely inhibitory where as lower concentrations (1%, 5%) were found stimulatory and reached up to the level of control. The present study showed that the distillery effluent was highly loaded with organic pollutants along with harmful heavy metals which showed significant effect on soil quality and the crop productivity which caused environmental injustice to the local people in terms of loss of crop productivity and environmental hazards.

Key words: Heavy metals; Effluent; Pollution; Soil chemistry; Environmental justice.

INTRODUCTION

Distillery industries plays major role in the environment pollution. The organic effluent (spentwash) 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). Many industries in Nepal discharge their effluent directly or indirectly into land or small channel leading to the nearby river due to which water quality of most of the rivers and streams get degraded. Such water is not safe for human being, livestock and irrigation. Industrial effluents 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). However, many farmers in urban areas are compelled to use polluted river water or direct industrial effluent to irrigate their cropland due to the absence of better alternatives (Ghimire, 1994).

A clean, healthy and safe environment is a fundamental right of all human beings. Concepts of environmental justice strongly address this fundamental right. 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. The principle of environmental justice demands that public policy be based on mutual respect and justice for all people from any form of discrimination or bias and principle number 6 demands the cessation of 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. It can be understood that principles of environmental justice focus on the right of all people to live in clean and healthy environment.

The interim constitution of Nepal 2007, guarantees the right to every person to live in a clean environment. This provision has potential for far reaching effects in addressing the disproportionate distribution of environmental hazards in urban areas with respect to marginalized groups and poor communities. (Belbase and Thapa, 2007). However, in Nepal most of the industries have been established without or with low quality waste water or effluent treatment plants. Such industries have brought adverse impact on the local environment of the industrial area. Mostly the farmers and low income resource people get affected by such industries. Beside these, there is not such distinct rules and regulation of compensation system which result poor people bear great loss. Hence, this study was undertaken to assess the injustice on concerned people due to the distillery effluent.

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MATERIALS AND METHODS

Sampling of the Industrial Effluent, Stream Water and Soil

For the present investigation, the effluent of the Karnali Distillery Pvt. Ltd. Khajura, Nepalgunj was collected in June 2006 when the factory was running at full capacity. Samples were collected in plastic bottles of one litre. For the analysis of heavy metals, effluent samples were acidified with HNO_3 (pH<2) at the time of collection following Trivedy and Goel (1986). Soil samples were collected from two sites i.e. crop fields irrigated with effluent mixed and non-effluent stream water in June and October 2006. About 500g of two soil samples from each site were collected in a zipper bag. Parameters of effluent such as temperature, pH, total suspended particles, dissolved oxygen, chemical oxygen demand, biological oxygen demand, nitrogen, phosphorus, and potassium, heavy metals such as lead (Pb), Zinc (Zn), Cupper (Cu), Manganese (Mn), Iron (Fe) and Cadmium (Cd) were analysed in the laboratory of Nepal Bureau of Standards and Measures, Balaju, Kathmandu. The germination experiment was carried out in the laboratory of Central Department of Botany, Tribhuvan University. Soil Analysis was done in Soil Science Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur and Regional Soil Experiment Laboratory, Khajura, Nepalganj, Banke.

Method of Effluent and Soil Test

All the analytical processes of effluent and heavy metals of soil were carried out according to the standard method for the examination of water and waste water (APHA, 1998). Soil samples were analyzed for total Nitrogen, Phosphorus and Potassium following Bajwa *et al.* (1997) where as Organic matter of soil was determined by using Walkley and Black's rapid titration method.

Germination Experiment

The seeds of paddy (*Oryza sativa*), var. 'Barse 3004' and wheat (*Triticum aestivum*) var. 'Bhrikuti' were used.The germination tests were carried out in Petri dishes at 26 ± 2°C. Ten 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 solutions were added to each Petri dish. A control experiment was carried out using distilled water. 1 ml of effluent was added at an interval of three days to keep the level of effluent constant. Seed germination was observed at the interval of 24 hour for five days and the emergence of radicle upto 2 mm in length was considered as a criterion for germination following Street and Opik, 1976. Root and shoot length were measured on each fifth day interval. After 15 days, seedlings were taken out from each Petri dish and their respective root and shoot length were measured. Seedling components were separated into root and shoot and measured separately for their fresh weight. These seedling parts were dried in an oven for 48 hour at 75°C and their respective dry weight was taken. Analysis of variance is the major statistical tool used in the study for testing the statistical significance of the variance of mean at P = 0.05. Overall statistical analysis (F-test) of the present study was done in the SPSS (10.1).

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 know the effluent and environmental justice.

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

S.N.	Parameter	Unit	Concentrate	Dilute	Stream water without effluent
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

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

SN	Parameter	Unit	Before Monson		After Monson		Average	
			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 non-effluent stream water. **Site B** - Irrigated with effluent mixed stream water.

RESULTS AND DISCUSSION

Physico-Chemical Parameters of Effluent

Effluent from the Karnali Distillery Pvt. Ltd., Khajura, Banke was dark brown in colour with strong odour. Comparatively almost all the parameters were found higher in concentrate and dilute effluent than in effluent non-mixed stream water.

The temperature of concentrate effluent of Karnali distillery was recorded 105°C where as that of dilute and the non-effluent stream water were recorded as 36°C and 30°C respectively. The effluent of Karnali distillery was highly acidic in nature with pH value of 3.7 and 4.0 in concentrate and dilute respectively. In contrast to this the pH value of the non-effluent 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-effluent 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 non-effluent 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 non-effluent stream water was found to be 12.6 mg/l, 0.3 mg/l, 16.8 mg/l, respectively. Biological oxygen demand and chemical oxygen demand values for concentrate effluent were 47520 mg/land 58400 mg/l, respectively, and that of dilute effluent were 15450 mg/l and 32100 mg/l, respectively. BOD and COD values of non-effluent stream 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 non-effluent water it was found to be 4.7 mg/l. The Manganese (Mn) content of concentrate and dilute effluent was analyzed to be 6.4 mg/land 5.7 mg/l, respectively where as in non-effluent 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 non-effluent stream water it was 0.01 mg/l. 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 non-effluent water. Similarly, Zinc (Zn) content in concentrate and dilute effluent were found to be 3.1 mg/l and 1.21 mg/l respectively, where as non-effluent stream water it was found to be 0.06 mg/l.

Effect of the Karnali Distillery Effluent on Soil Characters

The average pH value of soil irrigated with effluent mixed stream water was slightly lower (6.4) than that of irrigated with non-effluent stream water was (7.2). The organic matters content in average was higher with the value of 4.07 percent in the soil irrigated with effluent mixed water than in the soil irrigated non-effluent water was 0.52 percent. Organic matter content of soil irrigated by non-effluent water was less after monsoon where as it was found higher in soil irrigated by effluent mixed stream water after monsoon. The nutrients such as nitrogen, phosphorus and potassium were found higher in soil irrigated with effluent mixed water. Potassium was analyzed in sufficient amount in both soil i.e. irrigated by effluent mixed and non-effluent stream water. Nitrogen content in average was found slightly higher in the soil irrigated with effluent mixed water (0.17%) than in soil irrigated by non-effluent mixed water (0.1%). Except Zn all the analyzed heavy metals (Fe, Pb, Mn, Cd and Cu) content were found to be higher in

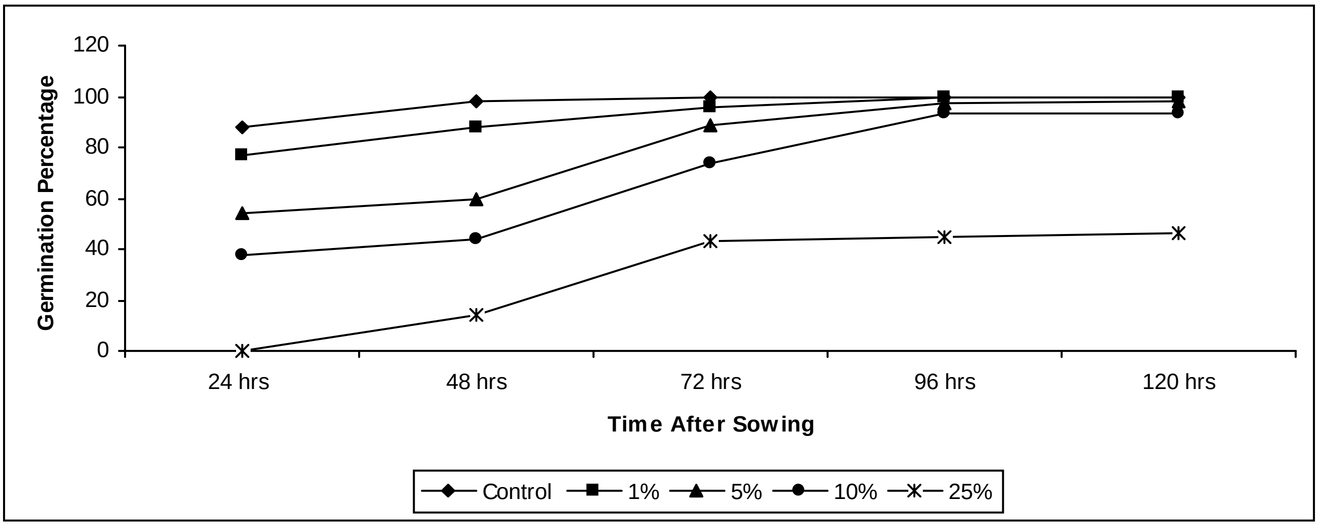

Fig. 1: Effect of effluent on seed germination of *Oryza sativa*. Variance ratio at 5% level Fcal=14.64 and 39.59 (Ftab=3.01 and 3.24) for hours of sowing and treatment concentration at d. f. (4, 16 and 5, 16).

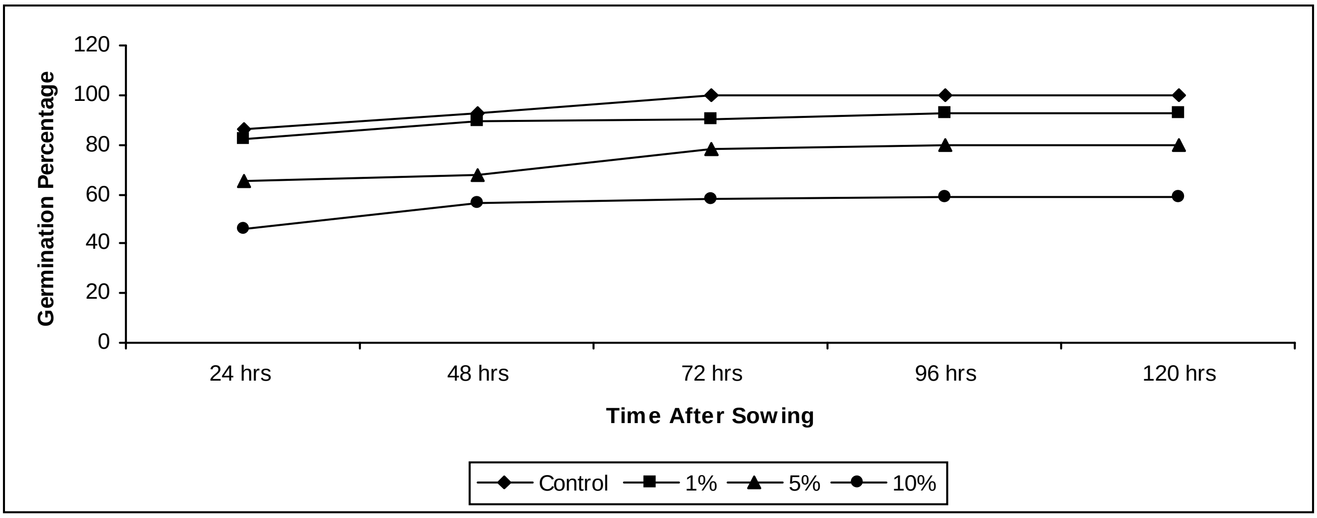

Fig. 2: Effect of effluent of seed germination of *Triticum aestivum*. Variance ratio at 5% level Fcal=14.87 and 205.89(Ftab=3.26 and 3.49) for hours of sowing and treatment concentration at d. f. (4, 12) and (3, 12) respectively.

the soil irrigated with effluent mixed water than in the soil irrigated with non-effluent water.

Seed Germination and Seedling Growth

Distillery effluent in different concentrations (1%, 5%, 10% and 25%) affect seed germination of paddy and wheat, (Fig 1, 2). Different concentrations of effluent bring significant change in the rate of seed germination. At lower concentration (1%, 5%) germinations was found to be nearly equal to the control but at higher concentration (10%, 25% in case of paddy and 5%, 10% in case of wheat) imposed inhibitory effect. Seed could not germinate above the concentration level of 25 percent.

Seedling growth of two test crops was significantly affected by the distillery effluent (Fig 3, 4). Lower concentration (1%, 5%) slightly enhanced the shoot growth of paddy. 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.

Lower concentrations of effluent (1% and 5%) increased the fresh weight of seedling in case of paddy where as the fresh weight of wheat was found decreased with the increase of effluent concentration (Fig 5). Effect of different concentration of effluent on dry weight of shoot and root of test crops was found statistically significant at $P = 0.05$. 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 similar to fresh weight 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 unlike to its fresh weight (Fig 6).

Crop Yield

The data obtained through interview with local people revealed that the average productivity of rice and wheat on the land irrigated with non-effluent stream water (Site A) was found to be around 4,810kg/ha and 837kg/ha, respectively, where as on the land irrigated with effluent mixed water (Site B) was

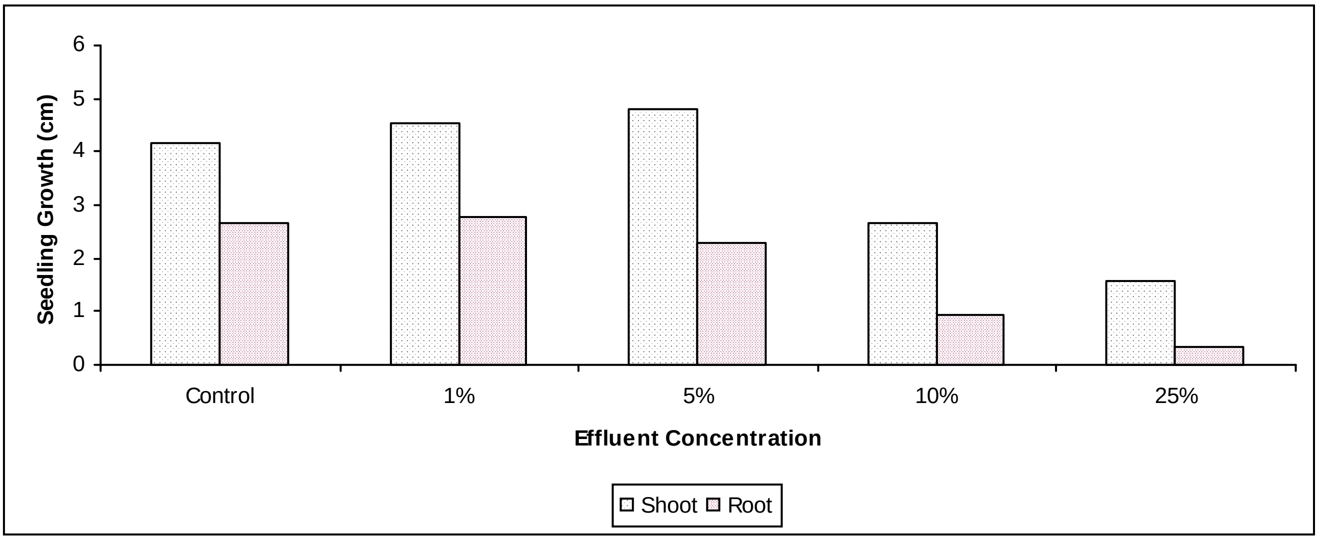

Fig3: Effect of effluent on seedling growth of *Oryza sativa*. Variance ratio at 5% level, Fcal=9.51, 6.96 (Ftab=3.84, 4.46) and Fcal 7.24, 5.10 (Ftab= 3.84, 4.46) for days of sowing and treatment concentration at d.f. (4, 8), (2, 8) for shoot and roots respectively.

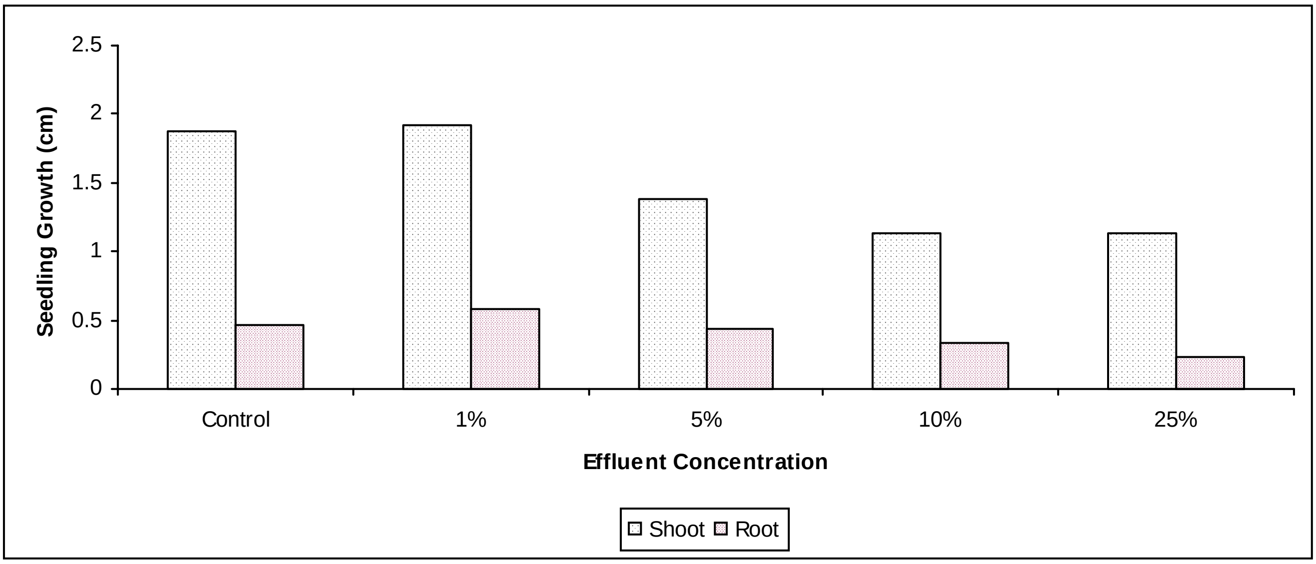

Fig. 4: Effect of effluent on seedling growth of *Triticum aestivum* variance ratio at 5% level, Fcal=23.23, 19.61 (Ftab=4.76, 5.14) and Fcal= 4.83, 6.06 (Ftab=4.76, 5.14) for days of sowing and treatment concentration at d.f. (3, 6) (2, 6) for shoots and roots respectively.

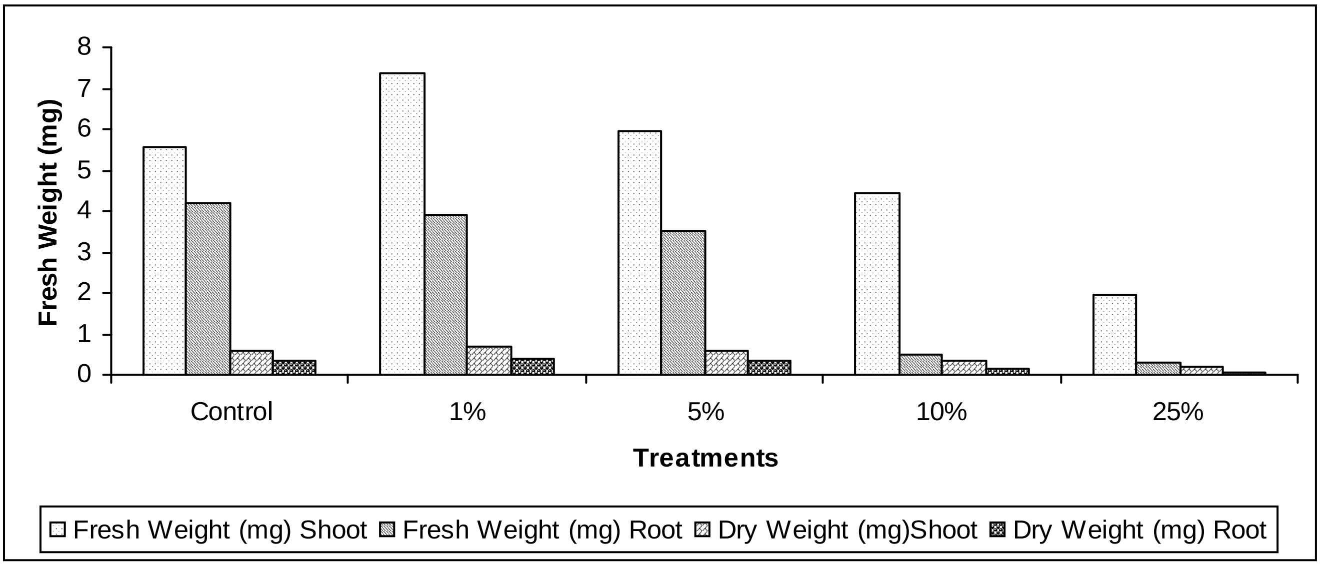

Fig 5: Effect of effluent on fresh and dry weight of *Oryza sativa* seedling, variance ratio at 5% level, Fcal=12.03 (Ftab=5.32) at d. f. (1, 8) and Fcal=4. 34 (Ftab=5. 32) at d. f. (1, 3) respectively with respect to effluent concentration.

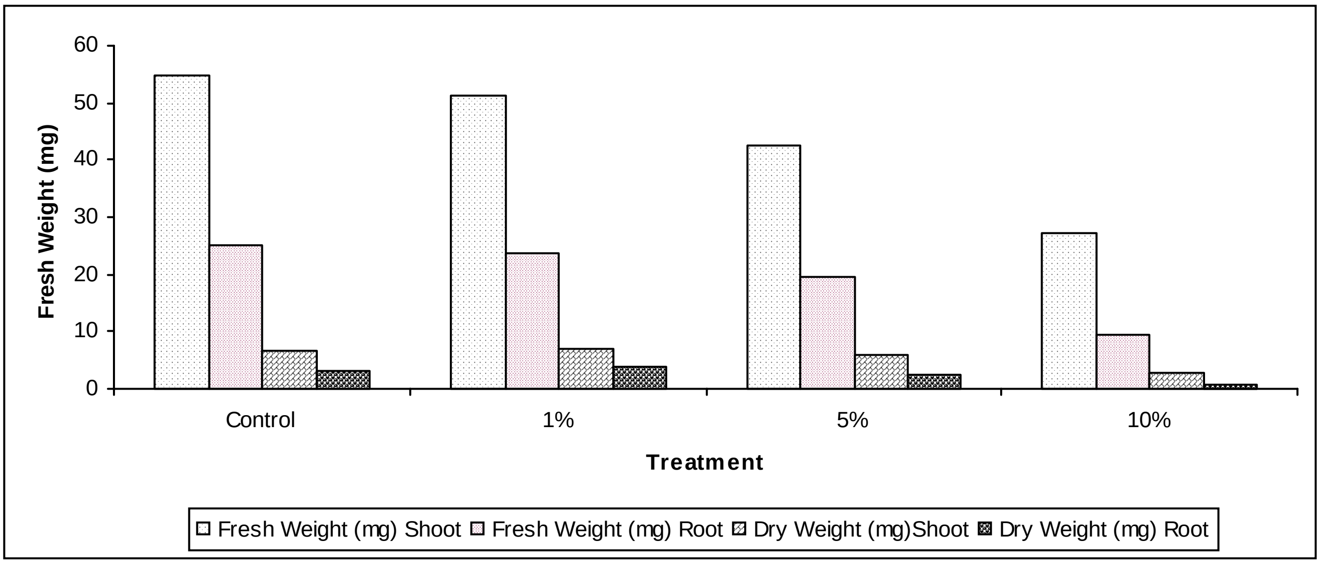

Fig 6: Effect of effluent on fresh and dry weight of *Triticum aestivum* seedling, variance ratio at 5% level, Fcal= 7.74 (Ftab=5.99) at d. f. (1, 6) and Fcal=7. 88 (Ftab=5. 99) at d. f. (1, 6) respectively with respect to effluent concentration.

found to be 2,477kg/ha and 688.8kg/ha, respectively (Fig 7).

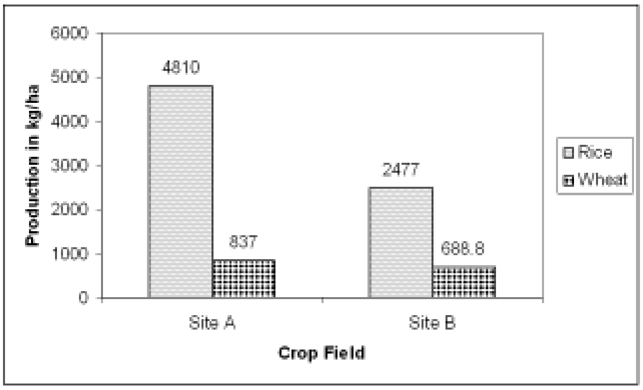

Fig. 7: Productivity of the crop fields irrigated by effluent non-mixed water (Site A) and effluent mixed water (Site B).

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

In the present study 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 non-effluent water it was slightly acidic. 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 less acidic than in the present report. The low pH of the distillery effluent might be due to the presence of higher concentration of organic acids such as CH_3 COOH.

The total suspended solid (TSS) of the concentrate and dilute effluent were found extremely higher than maximum limit fixed for a fermentation industry (NS, 1995) or any industrial effluent (NS, 1990). The high amount of TSS in the effluent indicated presence of high organic suspended solids. Devkota (1997) also analyzed the TSS of distillery effluents to be 11,230 mg/l which was similar to that of present study where as the TSS of non-effluent 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 non-effluent stream water. Low DO might be due to presence of high amount of oxygen demanding organic wastes. This result was very near to the Gewali *et al*. (1994) in carpet and dying effluent and Sharma and Rijal (1988) in carpet effluent.

N, P, K content in concentrate and dilute effluent were found much higher than non-effluent stream water. Among these three major plants nutrient K was found in highest amount followed by N and P. Mahimairaja *et al*. (2004) also reported the similar result.

BOD and COD in the effluent were found much higher in case of dilute effluent in comparison to non-effluent stream water. They were found to be higher than the tolerance limit fixed for any fermentation industry or any other industrial effluent (NS 1990, 1995). High BOD and COD might be due to presence of high oxidizable organic matter and rapid consumption of dissolved inorganic materials. Sah *et al.* (2000) and Devkota (1997) analyzed BOD and COD of distillery industry effluent which were found less than the present study but still higher than the tolerance limit.

In case of heavy metals, except Zn and Cu other heavy metals i.e. Mn, Fe, Pb and Cd were found much higher than the maximum permissible value fixed for industrial effluent (IS 1974, NS 1990). Fe content in concentrate and dilute effluent were found to be 115 mg/l and 102.4 mg/l, respectively. Abnormal level of Fe adversely effects the growth and causes other physiological disorder in paddy and other crop plants (Woolhouse, 1983). Likewise, high content of Pb inhibits the root growth and seed germination of source vegetable crops (Pokhrel *et al.* 2001). Similarly higher concentration of Cd inhibits uptake of P and K (Matsuo *et al.*, 1995). Sah *et al.* (2000) analyzed the Fe, Mn and Pb of Shree distillery and found to be 57.50 mg/l, 68.05 mg/l and 0.28 mg/l, respectively, which were higher than tolerance limit and similar to present study.

The soil irrigated with effluent mixed 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 by non-effluent water was found to be slightly basic with pH value 7.2. Decrease in the pH of distillery effluent mixed irrigated soil may attribute to the acidic nature of the spentwash and the release of organic acids during the decomposition.

The total average organic matter content in the soil irrigated with effluent mixed water was found to be higher than the soil irrigated with non-effluent water. The high amount of organic matter in soil irrigated with effluent mixed water might be due to the high organic nature of the effluent. Acharya (2001) also found the organic content in the soil irrigated with brewery industry effluent to be higher than in the soil irrigated with uncontaminated water.

The average values of N, P and K in the soil irrigated with effluent mixed water were found to be higher than in the soil irrigated with non-effluent stream water. The high amount of N, P and K in the soil was 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 present study. The soil amendment with distillery effluent for wheat and paddy cultivations affects the increase organic carbon and available potassium content of post harvest soils (Pathak *et al*., 1999).

Except Zn, the concentration of heavy metals Fe, Mn, Cu, Pb and Cd were found higher amount in the soil irrigated with effluent mixed water than in the soil irrigated with non-effluent water. Similar was the result by Sah *et al.* (2000) in the concentration of micronutrients (Zn, Fe, Mn and Cu) in the soil irrigated with paper industry effluent.

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 (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) also found the effect of distillery effluent on the growth of *Phaseolus aureus* and found stimulatory effect at lower concentration (1%-5%) and inhibitory effect (15%-20%) 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. It was observed that at lower concentrations (1% and 5% in case of rice) the seedling growth was stimulated according to which fresh weight and dry weight of seedlings was also found more in these treatments. But in case of wheat, fresh weight and dry weight of seedlings decreased with the increase of concentrations except of dry weight at 1 percentage concentration which showed little increase. Such types of effect of effluents on fresh and dry weight of seedling was due to desired level of nutrient in diluted condition but makes toxic level at high concentration. Similar result of increase or decrease of dry weight in case of different *Brassica* crops was obtained by Pokhrel (2000) with the treatment of different concentration of Pb and Cr.

It was observed that the average annual production rate of both rice and wheat of the land irrigated by non-effluent stream water was 2719kg/ha in average where as that of the land irrigated with effluent mixed water was 1583kg/ha which showed 40% less production. 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.

Environmental Justice

Karnali distillery is located near the human settlements and large agriculture land. Since more than twenty years the factory has been frequently discharging its effluent in the Kiran khola (a rivulet) near by the factory which is a main source of irrigation for marginalized local farmers. Local farmer have also been facing the problems of abortion and death of their cattle due to 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. 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, and Fe) and pH were also found very high. It has resulted in environmental hazards and decreased the cropland productivity which has become serious issue of environmental injustice to local farmers.

The farmers have to bear about 40 percent annual loss in crop productivity. This study verified the experience of the local farmers on the trend of decrease in productivity by interfering fertility of soil. Anonymous (2006) also reported that cropland of four village development committees (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 environmental injustice. To minimize the existing injustice to the local farmers and to guarantee the constitutional right to clean environment, the factory owner must compensate to local farmers and install measures to treat or minimize the load of pollutants in the effluent before it is discharged to the river.

CONCLUSION

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.

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