In India, the industries which cause edaphic environmental pollution include pulp and paper, fertilizer, textile, tanneries, sugar, distilleries, coal washeries, petro-chemical and carpet industries etc. When untreated effluents of these industries are discharged into the edaphic environment they disturb the ecological niches of living organisms. Since the sound technology for the complete treatment of the effluents and bringing it to desired health standard is yet to develop and the available techniques continue to be cost prohibitive, considerable attention is being paid to the recycling and utilization aspects of these industrial effluents [Singh et al., 2008].

Of all such options, the utilization of industrial effluents for irrigation is promising and is practiced widely as moisture is the first and the most critical factor even in humid tropics. In most of the areas the available water is always insufficient and plants are most vulnerable as they require adequate moisture. The use of industrial effluents in irrigation is a recent phenomenon with scientific attention towards this being focused only in the fifth decade of the last century when the problem of fresh water pollution due to effluent disposal became particularly acute. A large variety of industrial effluents viz., dairy effluents [Scott, 1962; Ajmal et al., 1984], food processing effluents [Fisk, 1964], pulp and paper factory effluents [Rajannan and Oblisami, 1979], distillery effluents [Behra and Mishra, 1982; Trivedi and Shinde, 1983; Sahai and Srivastava, 1986; Rani and Srivastava, 1990; Elecey, 1991], carpet industry [Singh, 2003; Singh et al., 2008], etc., are used for irrigation purposes. Besides, sewage water has been successfully used for irrigation of crops with or without any treatment [Sharma, 2004; Sharma, 2008a, b; Sharma et al., 2008; Parashar, 2009; Parashar et al., 2009; Sharma and Parashar, 2009a, b].

A good quality of water means its suitability for use and it has the potential to allow maximum yield under good soil and water management practices. On the contrary, with poor quality of water and soil, problems are expected to develop which reduce the yield and deteriorate the soil quality.
Several aspects of industrial effluents have been worked out by a number of investigators. Jackson (1968), Brydges and Briggs (1968), Downing and Edwards (1968), Boon (1969), Curtis (1969), Albaster (1970), Wheatland and Bruce (1970), Boon and Borne (1971), Alabaster (1972) have studied various treatments and discussed the criteria for the quality of trace elements in irrigation water. Termann et al., (1973) have investigated the effect of municipal waste compost on crop yield and nutrient in green-house experiments. Mehrotra and Das (1973) have studied the influence of exchangeable sodium on the chemical composition of important crops at different stages of growth. Milford et al., (1977) discussed the effects of sodium chloride on water status and growth of sugar beet. Rajannan and Oblisami (1979) have studied the effects of paper factory effluents on soil and crop plants. Mhatre and Chapekar (1980) have studied the effect of industrial pollution on a river ecosystem. Behra and Mishra (1982) have reported the effects of industrial effluents on growth and development of rice seedlings. Trivedi and Shinde (1983) have studied the effects of distillery waste irrigation on soil characteristics. Mishra (1983) has examined the influence of carpet industry wastes on various aspects of wheat crop ecosystem. Behra and Mishra (1983) examined the effect of molasses distillery effluents on rice seedlings. Ajmal et al., (1984) evaluated the physico-chemical characteristics of industrial dairy processing effluents and monitored the effects of their discharge directly on fertile soil and indirectly on the growth and development of Phaseolus aureus and Pennisetum typhoides. Sahai and Srivastava (1986) examined the effects of distillery effluents on seed germination, seedling growth and pigment content of Cajanus cajan. Jha (1988) has examined the influence of fertilizer factory effluents on various aspects of Eleusine corocana crop ecosystem. Srivastava et al., (1988) have studied the seasonal accumulation of nitrate and ammonium in Cynodon dactylon in relation to nitrogen fertilizer. Choudhary (1967) studied the seasonal changes in the standing crop, annual net production and energetics of Dichanthium annulatum stands. Chaudhary and Tripathi (1989) studied the effect of heavy metals in amelioration of environmental extremeness in a salt-affected habitat. Rosas et al., (1989) have examined some aspects of the environmental exposure on chromium residues. Karunaichamy et al., (1990) have
estimated heavy metal concentration and dry matter production of sewage water on a few grass species. Otabbeng (1990) examined the chemistry of chromium in some Swedish soils. Renu and Srivastava (1990) evaluated ecophysiological response of distillery effluents on *Pisum sativum* and *Citrus maxima*. Bogacz *et al.*, (1993) have analyzed the accumulation of heavy metals in the soil and plants. Elecey and Tiwari (1991) have examined the effect of distillery effluents on germination, growth and chlorophyll content of finger millet (*Eleusine coracana*). Park (1991) has analyzed the seasonal variation of residual effects of nitrogen and potassium fertilizer in grasslands. Manino and Pepper (1992) studied the influence of secondarily treated municipal wastewater irrigation on the chemical quality of Bermuda grass. Manonmani *et al.*, (1992) have observed the effect of photofilm factory effluents on seed germination and seedling development of some crop plants.

Eleiwa *et al.*, (1997) studied the effect of dried sewage sludge from two sources (Suez and Giza) on faba bean growing on sandy soil followed by sorghum to test the residual effect of the sludge on its growth and mineral content in pot experiments. The results showed that for faba bean the number of nodule/plant, plant height and leaf area increased significantly due to application of either Suez or Giza sludge up to 5%. The former sludge increased yield up to 5% while the later gave only 2.5% increase. Data also revealed that shoot and root dry weight of sorghum plant were significantly increased by Suez and Giza sludge by 7.5% and 5% respectively. The higher rate (10%) of Giza sludge inhibited the root growth, N and P content increased by either of the sludge application. Zn and Cr content of root and shoots increased by increasing the Suez sludge while Fe, Mn and Mo content of roots were slightly affected and remained unchanged in the shoots. Giza sludge application caused progressive increase in most of the heavy metals in sorghum especially in chromium. According to the Zn equivalent the maximum rate of dried sludge to be added to the soil was estimated to be 78.13 tons/feed for Giza sludge and 160.25 tons/feed for Suez sludge before the safe limits are exceeded. The addition may be divided over long period.

Prasad *et al.*, (1997) have found that effluent discharge from cycle industry released in water bodies and crop fields results in accumulation of chromium and nickel
in weeds such as *Eichhornia* and cereals like wheat. Bansal (1998) has observed an increased level of heavy metals in fields irrigated with sewage. Ginnocchio (2000) has studied the changes in the soil characteristics and plant community dynamics around a copper smelter established in 1964 in Puchincavi Valley, Central Zone of Chile and has found a decrease in soil nitrogen, species abundance and regeneration capabilities of plants.

Singh (2003), Singh *et al.*, (2008) evaluated the physico-chemical characteristics of carpet industry effluents and monitored the effects of their discharge directly on fertile grassland soil and indirectly on the growth and development of two dominant grassland species *Bothriochloa pertusa* and *Cynodon dactylon*.

Singh (2003), Singh *et al.*, (2008) have reported that the standing dead was maximum in December due to death of living parts. After December shedding, falling and decaying of standing dead parts (stem and leaf) takes place which reduces the biomass of standing dead parts. The underground biomass is affected by above ground production. The underground biomass increased from rainy to winter seasons and decreased in summer season. In general, an increase in the underground biomass is expected in the beginning of the dry season due to the translocation of materials from the photosynthetic parts. But there the trend was not in accordance with this generalization and a continuous decrease in underground biomass was observed throughout summer.

Productivity of green plants is one of the most important functional attributes of the ecosystem which provides basic energy and matter for all the other parts of the system. The net primary productivity of *Dichanthium annulatum* and *Cynodon dactylon* was found to be maximum in rainy season in both types of grasslands. This may be attributed to three reasons (i) favourable soil moisture, (ii) high assimilation rate and (iii) the greater efficiency of roots of these grasses in picking up the moisture (Spedding, 1971; Singh, 2003). The age of the plant also plays a dominant role in the difference in dry matter production. During certain period of growth the productivity value went beyond compensation point. A decrease in dry matter is caused by the senescence of leaves due to the degradation of photosynthetic pigments. Also a
reduction is brought forth by decrease in photosynthetic area, chlorophyll, water, phosphorous and protein contents of the photosynthetic parts (Dwivedi, 1970) which all are responsible for lowering the productivity. Further high respiration rate associated with high temperature could also result in low rate of net photosynthesis and thus low rates of growth further reducing the productivity. The total net production of standing crop is much higher on control as compared to polluted grassland. The fact that the control is free from pollution seems to be responsible for greater biomass accumulation and increase in production on control whereas the decreased net production of the polluted grassland species can be attributed to the toxic effects of effluents which have been shown to increase in the content of heavy metal chromium in soil above critical level (Singh, 2003, Singh et al., 2008).

Turn over values have been expressed as the ratio of net annual increment to maximum biomass in contrast to the method of Dahlman and Kucera (1965) who calculated turnover on the basis of difference of maximum and minimum biomass. The method used here is advantageous in the sense that real organic matter production is the sum of positive differences rather the difference of maximum and minimum biomass. Therefore, it is possible that the turnover value may be more than one when the productivity is more than maximum biomass. The turnover value of the total community was recorded 0.51 and 0.58 on control and polluted grasslands respectively. The turnover value of the underground parts was studied Mishra (1968), Billore (1973), Pandey (1977, 1978), Singh (2003), Singh et al., (2008).

Industries require water in large quantity. After its use the wastewater is let out as effluent containing acids, alkalies, heavy metals, toxic inorganic and organic compounds, colour producing substances in dissolved and suspended forms. When the soil receives these industrial effluents by irrigation and other means it gets adversely affected. Similar biological communities often occupy soils of similar types (Singh, 2003; Singh et al., 2008).

Sharma et al., (2008), Gautam (2009), Parashar (2009), Sharma and Parashar (2009a, b) have discussed the adverse effects of excessive sodium and other salts in the irrigation water on soil and plant growth. Thus, the high concentration of sodium, calcium, chloride, potassium, ammonium, sulphate, chromium, carbonate and soapanified water at alkaline pH may cause detrimental effect on the physico-chemical properties of the soil and growth of the plants growing in such soils.

High alkalinity, salinity and sodicity of the effluents may also adversely affect the soil. Paliwal et al., (1976) have emphasized that the alkalinity and salinity of irrigation water is the cause of alkaline and saline soils in Rajasthan. In addition to dissolved chemicals, suspended chemical substances, dye, dust and dirt particles from wool surface and wool particles are responsible for very high content of total solids in the effluents which were found to be alarmingly higher (1678.00, 1722.00 and 1745.00 mg/l) in effluents from polluted site and relatively much lesser (35.75, 38.67 and 42.22 mg/l) at control site during rainy, winter and summer seasons respectively by Singh (2003), Singh et al., (2008). Also the values of dissolved solids were much higher at polluted site i.e., 989.85, 1023.00 and 1045.26 mg/l during rainy, winter and summer seasons respectively. Very little amount of dissolved solids were recorded at control site i.e., 63.85, 77.60 and 85.10 mg/l during corresponding seasons respectively in comparison to polluted site. The values of suspended solids recorded at polluted site were 266.14, 284.56 and 299.55 mg/l during rainy, winter and summer seasons respectively. The control site was free from suspended solids (Singh, 2003; Singh et al., 2008).

The increase in dissolved, suspended and total solids of water deteriorates the suitability of its quality for plant growth. The solid content is directly proportional to the chemicals present in the water which may prove toxic to the plants. As these solids require huge amounts of biochemical oxygen for their decomposition the effluent receiving soils show oxygen deficiency and may adversely affect the growth activity of the plants. The suitability of water for irrigation is determined by the amount and kind of salts present therein. A continuous supply of such effluents may also lead to
increased level of heavy metal chromium which can prove toxic for growth of plants in due course of time.

Green plants convert light energy into chemical energy which is used in synthesis of organic matter which in turn increases the biomass. The organic matter produced by green plants in terms of biomass is called the *primary production* and its expression in relation to time is called *primary productivity*. The concept of productivity in plants is viewed from two angles:

3. Gross production

The *gross production* is the total gain in organic matter obtained by photosynthesis during growing period. A part of this photosynthetic product is consumed in respiration of the living tissue and the remaining is stored as plant biomass. The part of the organic increment that is not consumed in respiration is commonly termed as the *net production*.

The *turn over* is another important attribute denoting the ratio of net annual increment.

Water is a universal solvent and medium of solutes and raw materials in various forms and functions. It is an important ecological factor in the life of living organisms. Water relations of plants bring about in them many physiological by affecting transpiration, respiration translocation, photosynthesis, seed germination, uptake of nutrients, growth and some biochemical processes. The concentration and composition of dissolved and suspended constituents in water determine its quality for use of plants. The dissolved salts in water can change the physico-chemical properties of soil by affecting the chemical composition and concentration of the soil solution and subsequently that may affect the cations present in the soil water exchange complex. The changes in soil properties may be beneficial or harmful depending upon concentration and nature of dissolved constituents of water and the original character of the soil. However, the concentration of various ions in water and soil of a particular habitat varies with respect to rainfall, temperature and plants inhabiting it. Therefore, the
relationship between certain ions and the amount of water they are dissolved in must be considered.

Effluent from industries are normally considered as the main pollutants as they contain various colours, tastes, odour, organic and inorganic compounds, acids, alkalies and other materials in dissolved and suspended forms. When these effluents are discharged into the environment, they disrupt the ecological niches of living organism. A knowledge of physico-chemical properties of the effluent is very essential for understanding their effects on the biota and soil of the ecosystem receiving such discharges from the industries.

Patterson (1971) has reported that metal toxicities of plants of arise from industrial wastes. King et al. (1972) have studies the land disposal of liquid sewage sludge and its effect on yield, in vivo digestibility and chemical composition of coastal Bermuda grass (*Cynodon dactylon*). Leeper (1972) has studies the relations of sewage waste heavy metals with soils. Chaney (1973) has investigated the crop and food chain effects of toxic elements in sludges and effluents. Terman et al. (1973) have investigated the effects of municipal waste compost on crop yields and nutrient content in greenhouse pot experiments.

Tylor et al. (1974) have studied the environmental effects of chromium and zinc in cooling water drift and transfer of chromium and zinc to vegetation. Bradford et al. (1975) have reported the trace element concentrations of sewage treatment plant effluents and sludges, their interactions with soils and uptake by plants. Mortvedt and Giordano (1975) have studied the response of corn to zinc and chromium in municipal wastes applied to soil. Bates et al. (1976) in Canada have studied the land disposal of sewage sludge for the abatement of municipal pollution. Kumar (1972) has analysed the wastewater discharge from six different industries and reported the occurrence of some pollution tolerant algae. Kothandaranna et al. (1974) have reported that proper treatment should be given to the industrial effluents before their disposal from the explosive factory because the industrial effluents contain several harmful substances. Paliwal (1977) has discussed the pollution of surface and ground water. Tripathi (1975) has
studied the physico-chemical properties of effluent and the affected soils around a fertilizer factory at Sahupuri near Varanasi.

As regards the physico-chemical properties of the effluents from carpet industries very little information is available about grassland soil alteration. In India, Mishra (1983) has done a little amount of research on this aspect. Present physico-chemical analysis of effluents in an attempt to obtain necessary basic information for evaluation of its effect on soil characteristics and ultimately on plant growth.

OBJECTIVES

As not many studies have been performed to examine the toxic effects of various substances found in industrial effluents especially heavy metals like Hg, Ni, Cd, Pb and Cr etc., on biomass, productivity and turnover in the grassland species the study was undertaken to examine the physico-chemical and biological characterization of the industrial effluents discharged into the nearby grassland soils affected. The objective of this work was to evaluate the effect of various toxic substances found in the industrial effluents on grassland species so as to provide information on the significance of biomass, productivity and turnover in two dominant and other grassland species from industrially polluted grassland. In the present study two dominant grassland species were investigated with respect to biomass, productivity and turn over along with other species of control and polluted grassland sites selected from Industrial Area of Agra, Uttar Pradesh, India.