CHAPTER- 6

CONCLUSIONS AND DISCUSSIONS

Detailed analysis of extensive data obtained by experiments results in arriving at following conclusions. Statistical analysis of the database using software "**MegaStat Version 9.1**" helped in evaluating various impacts both qualitatively and quantitatively. Our ultimate aim was to arrive at a proper blend of treated sewage effluent and fresh water such that we get higher yield of grain which is least toxic for human consumption and leads to conservation of fresh water resources to a large extent.

The following conclusions are made in connection with various **environmental impacts**.

6.1 Quantitative Aspects of Wheat

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest yield level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest yield level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest yield level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Wheat yield are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.2 Qualitative Aspects of Wheat

6.2.1 Protein content

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Protein content respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Protein content respectively.

3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Protein content respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Protein content are not significant at the 0.05 significance level.

6.2.2 Pb level in wheat grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest lead level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest lead level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest lead level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Lead level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002, the maximum permissible limit of lead is 2 ppm in foods (category not specified). The concentration of lead found in each treatment does not exceed said permissible limit. Hence wheat grains are safe (in varying degrees i.e. T1N1 to T7N3) for human consumption.

6.2.3 Cu level in wheat grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Copper level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Copper level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Copper level respectively.

4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Copper level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8th Amendment) Rules, 2002, the maximum permissible limit of copper is 30 ppm in foods (category not specified). The concentration of copper found in each treatment does not exceed said permissible limit. Hence wheat grains are safe (in varying degrees i.e T1N1 to T7N3) for human consumption.

6.2.4 Zn Level in wheat grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Zinc level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Zinc level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Zinc level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Zinc level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8th Amendment) Rules, 2002, the maximum permissible limit of Zinc is 50 ppm in foods (category not specified). The concentration of Zinc found in each treatment does not exceed said permissible limit. Hence wheat grains are safe (in varying degrees i.e. T1N1 to T7N3) for human consumption.

6.2.5 Mn level in wheat Grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Manganese level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Manganese level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Manganese level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment are significant whereas the main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.
5. Manganese is not included in list of poisonous metals (in various articles of foods) prescribed by the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002.

6.2.6 Fe level in wheat grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Iron level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Iron level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Iron level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Iron level are not significant at the 0.05 significance level.
5. Iron is not included in list of poisonous metals (in various articles of foods) prescribed by the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002.

6.3 EC of Soil (Wheat Cultivation)

1. As far as individual Irrigation Treatment is concerned, T3 and T7 reflect highest and lowest Electrical conductivity respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Electrical conductivity respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T3N1 and T7N3 reflect highest and lowest Electrical conductivity respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Electrical conductivity are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.4 Heavy Metals in Soil (Wheat Cultivation)

6.4.1 Pb level in soil under wheat cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest lead level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest lead level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest lead level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Lead level are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.4.2 Cu level in soil under wheat cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Copper level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Copper level respectively.

3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Copper level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Copper level are not significant at the 0.05 significance level.

6.4.3 Zn level in soil under wheat cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Zinc level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Zinc level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Zinc level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Zinc level are not significant at the 0.05 significance level.

6.4.4 Mn level in soil under wheat cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest Manganese level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Manganese level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest Manganese level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Manganese level are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.4.5 Fe level in soil under wheat cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Iron level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Iron level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Iron level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Iron level are not significant at the 0.05 significance level.

6.5 Quantitative Aspects of Greengram

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest yield level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest yield level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest yield level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Greengram yield are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.6 Qualitative Aspects of Greengram

6.6.1 Protein content

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Protein content respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Protein content respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Protein content respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Protein content are not significant at the 0.05 significance level.

6.6.2 Pb level in greengram grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest lead level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest lead level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest lead level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Lead level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002, the maximum permissible limit of lead is 2 ppm in foods (category not specified). The concentration of lead found in each treatment does not exceed said permissible limit. Hence greengram grains are safe (in varying degrees i.e. T1N1 to T7N3) for human consumption.

6.6.3 Cu level in greengram grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Copper level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Copper level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Copper level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Copper level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002, the maximum permissible limit of copper is 30 ppm in foods (category not specified). The concentration of copper found in each treatment does not exceed said permissible limit. Hence greengram grains are safe (in varying degrees i.e. T1N1 to T7N3) for human consumption.

6.6.4 Zn level in greengram grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Zinc level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Zinc level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Zinc level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Zinc level are not significant at the 0.05 significance level.
5. As per the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002, the maximum permissible limit of Zinc is 50 ppm in foods (category not specified). The concentration of Zinc found in each treatment does not exceed said

permissible limit. Hence greengram grains are safe (in varying degrees i.e. T1N1 to T7N3) for human consumption.

6.6.5 Mn level in greengram grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Manganese level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Manganese level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Manganese level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Manganese level are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.
5. Manganese is not included in list of poisonous metals (in various articles of foods) prescribed by the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002.

6.6.6 Fe level in greengram grains

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Iron level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Iron level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Iron level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Iron level are not significant at the 0.05 significance level.
5. Iron is not included in list of poisonous metals (in various articles of foods) prescribed by the Prevention of Food Adulteration (8^{th} Amendment) Rules, 2002.

6.7 EC of Soil (Greengram Cultivation)

1. As far as individual Irrigation Treatment is concerned, T3 and T7 reflect highest and lowest Electrical conductivity respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Electrical conductivity respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T3N1 and T7N3 reflect highest and lowest Electrical conductivity respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Electrical conductivity are not significant at the 0.05 significance level.

6.8 Heavy Metals in Soil (Greengram Cultivation)

6.8.1 Pb level in soil under greengram cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest lead level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest lead level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest lead level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment on Lead level are significant whereas main effects of Fertilizer Treatment on the same are not significant at the 0.05 significance level.

6.8.2 Cu level in soil under greengram cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Copper level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Copper level respectively.

3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Copper level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Copper level are not significant at the 0.05 significance level.

6.8.3 Zn level in soil under greengram cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Zinc level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Zinc level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Zinc level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Zinc level are not significant at the 0.05 significance level.

6.8.4 Mn level in soil under greengram cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T4 reflect highest and lowest Manganese level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Manganese level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T4N3 reflect highest and lowest Manganese level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Manganese level are not significant at the 0.05 significance level.

6.8.5 Fe level in soil under greengram cultivation

1. As far as individual Irrigation Treatment is concerned, T1 and T7 reflect highest and lowest Iron level respectively.
2. As far as individual Fertilizer Treatment is concerned, N1 and N3 reflect highest and lowest Iron level respectively.
3. As far as combination of Irrigation Treatment and Fertilizer Treatment are concerned, T1N1 and T7N3 reflect highest and lowest Iron level respectively.
4. By analysing F and p-value in hypothesis testing (two factor analysis of variance), it is found that main effects of Irrigation Treatment as well as Fertilizer Treatment on Iron level are not significant at the 0.05 significance level.

6.9 Impacts on Groundwater Quality

Land application of blended wastewater does not deteriorate the ground water quality as evident by close monitoring of various bore well water samples as well as samples from the bore well used in the experiments. This is in agreement of earlier cited literature that contaminant does not infiltrate to lower strata of ground water. Hence, it can be concluded that ground water is not contaminated as a result of application of sewage water for irrigation of wheat and greengram crop.

6.10 Impacts on Public Health

The lead level in workers associated with sewage water irrigation for wheat and greengram crops is found within normal range as a result of test of lead estimation by Atomic Absorption.

Bilirubin total, Bilirubin Conjugated, Bilirubin unconjugated and S.G.P.T. values in above workers are found within normal range as a result of biochemical investigations on Cobas Integra 400 (Roche).

Polymorphs, Lymphocyte, Eosinophil, Monocytes and Basophil values in above workers are found within normal range as a result of test of differential Leucocyte count.

Platelet value in above workers is found within normal range as a result of the test.

Hence, it is concluded that application of sewage water for irrigation of wheat and greengram crops does not cause any adverse effect on health of concerned workers.

6.11 Scores under Priority wise Conditional Impacts

Scores under priority wise conditional impact are determined for all treatments undertaken in experiment for wheat and greengram production.

For treatment T1N1 (100% sewage water and 100% nitrogenous fertilizer), we can see highest concentration of heavy metals in grain and soil and total score is 12.92 and 7.85 for wheat and greengram respectively.

For treatment T7N3 (100% surface water and 50% nitrogenous fertilizer), we can see least concentration of heavy metals in grain and soil and total score is 90.34 and 90.44 for wheat and greengram respectively. This however does not mean that surface water produces toxic grains. An explanation can be offered for this anomaly. Surface water is really good for irrigation. But an addition of 50% nitrogenous fertilizer leads to the increase in toxicity.

Above results certainly point out that some blending is required to produce less toxic grains. Our objective is to arrive at proper blending ratio so as to conserve fresh water of good quality.

Hence, it is concluded that treatment T6N3 (blend of 33.33% sewage water with 66.66% surface water and 50% nitrogenous fertilizer) ensures highest level of safety as far as human consumption of wheat and greengram grains is concerned. This treatment saves 33.33 % of good quality of water resources (i.e. ground water and surface water). Also, it significantly reflects the saving in application of nitrogenous fertilizer by 50%, because in this treatment only 50% of recommended dose of nitrogenous fertilizer was applied.

For treatment T5N3 (66.6 % sewage water & 33.3 % surface water and 50% nitrogenous fertilizer), the total score for wheat and greengram is 38.32 and 50.89 respectively. While for treatment T6N3 (33.3 % sewage water & 66.6 % surface water and 50% nitrogenous fertilizer), total score for wheat and greengram is 51.38 and 61.71 respectively.

Hence, treatment T6N3 ensures greater safety compared to treatment T5N3 as far as concentration of heavy metals in grains and soil is concerned.

6.12 Socioeconomic Impacts

The following conclusions are made in connection with **socioeconomic impacts**.

1. The crop production is significantly increased with availability of sewage water for irrigation in addition to available rainwater.
2. The overall cropping intensity is also significantly increased with availability of sewage water for irrigation in all three seasons.
3. More herd milk production is reported by beneficiaries of wastewater irrigation.
4. As far as attack of sickness is concerned, there is no any significant difference between wastewater users and non-wastewater users.

Therefore, it is concluded that wastewater users have better socioeconomic conditions than non-wastewater users.