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Suitability Assessment of Groundwater Quality for Irrigation Purpose: A Case Study

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Abstract: In order to assess the suitability of groundwater for irrigation purpose a comprehensive study was undertaken for the twin industrial towns namely Nalagarh and Baddi of Solan district, Himachal Pradesh, India. A total of 25 and 40 groundwater samples were collected, from 65 different locations of Nalagarh and Baddi industrial areas during post-monsoon season of 2011 and pre and post-monsoon seasons of 2012. The overall magnesium hazard (Mg haz.) values of groundwater were ranged from 26.83-61.209 and 19.958-64.478 at Nalagarh and Baddi industrial areas respectively. The overall averaged magnesium hazard value at Nalagarh and Baddi industrial areas were found less than 50, hence suitable for irrigation purposes. The findings also suggest that higher values of magnesium hazard of groundwater are restricted to a few localized areas. For better agriculture production, serious and proper attention should be given by the agricultural authorities to the locations having magnesium hazard of more than 50. This study which is based on magnesium hazard of groundwater can be considered as an eye opener.
Keywords: Magnesium hazard, Groundwater, Platykurtic, Nalagarh, Baddi.

I. INTRODUCTION

Water is considered as a key input for sustainable development. The National water policy 2012 identifies the needs of water for various purposes and prioritized them as water for drinking and domestic needs, water for agriculture and water for industrial use [1]. Nowadays increased agricultural and industrial activities have exerted heavy pressure on our vast but limited fresh water resources [2]. As the surface water sources are limited and restricted to particular stretches/regions hence, more than 70% population of India dependent on groundwater (directly or indirectly) for domestic, agriculture and industrial purposes. Groundwater quality is strongly influenced by various hydro-geochemical processes and is largely contaminated by both organic as well as inorganic pollutants [3]. Hence, it is necessary to determine the suitability of groundwater for the domestic and irrigation purposes based on the presence of major ions (cations and anions) and trace elements (heavy metals particularly) in it. In India, since last couple of decades three major factors such as: i) population growth ii) industrialization and iii) expansion of agriculture, forced significantly for over exploitation of ground and surface water sources. Several studies related to ground and surface water quality on drinking water standards have been carried out by several researchers [4-20]. Studies also suggest that if the quality and quantity of water (groundwater in particular) will deteriorate up to a certain level then it could unfit for domestic use, reduces the agriculture production and hinders industrial activities also.

Agriculture is the oldest industry in the world and the largest even today. Primarily, agriculture has to supply food for an increasing populated nation like India. It supplies raw material to the non-agricultural sector, as food for processing, and in the form of fodder, fibres, timber, charcoal, etc. Agricultural expansion improves the living standards of the majority of the people, and raises their purchasing power, also expands scope for industrialization. Therefore, the importance of agriculture in the economic development of a country is undebatable. The major part of the population of the world is dependent upon it for a living. In Indian context, agriculture produces around 50% of Gross Domestic Product while services account for 35% of it and industry for only 15%. Thus, the predominance, of agriculture sector rather than manufacture sector becomes main determinant of growth of economy. Realizing the importance of agriculture, a systematic study was planned and conducted to assess the suitability of groundwater of the two adjoining towns called Nalagarh and Baddi for irrigation purposes. For this the magnesium hazard (Mg haz.) was calculated and discussed subsequently.

II. MATERIALS AND METHODS

A. Description of Study Area

To assess the seasonal variation of quality of groundwater of two adjoining towns of the hill state, Himachal Pradesh in the north of India, a study has been carried out. Solan district is located between the latitudes 30° 03′ 00″ to 31° 09′ 00″ N and longitudes 76° 25′

12″ to 77° 12′ 00″ E. The adjacent towns, namely Nalagarh and Baddi of district Solan in the hill state of Himachal Pradesh, had been selected for the study. Nalagarh and Baddi tehsils are located between the latitudes 30° 54′ 23″ to 31° 14′ 36″ N and longitudes 76° 35′ 21″ to 76° 51′ 30″ E. Natural storm drainage to the twin industrial towns of Nalagarh and Baddi is provided by a perennial river, named Sirsa. The river enters the Solan district near Baddi and soon enters the Punjab state. Near Ropar, it finally merges with river Sutlej. Secondary drainage of the region is provided by a number of tributaries, major among which are Chikni Khud near Nalagarh and Balad Nadi at Baddi [1]. The cropping pattern of the study area is wheat and mustard during winter season and rice, pearl millet and sorghum during summer season [1].

B. Sampling of Groundwater

A total of 25 and 40 groundwater samples were collected, from 65 different locations of Nalagarh and Baddi industrial areas of Solan district, Himachal Pradesh. Sampling of groundwater samples was carried out from post-monsoon season 2011 to post-monsoon season 2012. The sampling sites were identified after reconnaissance of Nalagarh and Baddi industrial areas of Solan district, so as to represent the whole area. All the precautions were taken as given in standard methods for sampling and analysis [21].

C. Analytical Methods

The water samples were analysed at the Department of Civil Engineering in Environmental Engineering Laboratory (M.M. Engineering College, M.M University, Mullana) and all the precautions were taken as per standard methods [21]. The analysed parameters/elements are magnesium (Mg^{2+}) and calcium (Ca^{2+}). In order to calculate the magnesium hazard (Mg haz.) of groundwater for irrigation, following equation/formula was used (for calculation all values were taken in meq/l):

Mg haz. = (Mg^{2+} x 100) / (Ca^{2+}+Mg^{2+}) ……………………(i) [22]

Magnesium hazard (Mg haz.) values were calculated and presented in Figures 1, 2, 3, 4, 5 and 6.

III. RESULTS AND DISCUSSIONS

Magnesium hazard (Mg haz.) is an important parameter to evaluate the hazardous effect of Mg^{2+} to irrigation water. The degree of hazard effect would increase with the increase magnesium to calcium ratio. The adverse effect of magnesium hazard will develop in the soil when the ratio exceeds 50 meq/l [22].

A. Magnesium Hazard (Mg haz.) of Nalagarh Industrial Area

The magnesium hazard of the groundwater samples of industrial area of Nalagarh varied from a minimum value of 26.944 at sampling location N20 to a maximum value of 56.974 at sampling location N10 during post-monsoon season 2011, minimum 30.208 at sampling location N11 to maximum 61.209 at sampling location N10 during pre-monsoon season 2012 and minimum 26.83 at sampling location N20 to maximum 57.325 at sampling location N22 during post-monsoon season 2012. All the observations have been presented in Figures 1 and 5 (i, ii and iii). The average values of magnesium hazard (at individual sampling locations) varied from a minimum value of 28.587 at sampling location N20 to a maximum value of 58.456 at sampling location N10 (Figures 2 and 5iv). The average values of magnesium hazard (average of all the 25 samples) were found to be 38.924±7.994, 42.826±7.746, and 41.287±8.751 during post-monsoon season 2011, pre-monsoon season 2012, and post-monsoon season 2012, respectively thus accounting for an overall average magnesium hazard value of the groundwater samples of industrial area of Nalagarh as 41.012±7.854 (Figure 5iv). The results shows 16% (Inference drawn from sampling locations N4, N10, N22, N23 during post-monsoon season 2011); 20% (Inference drawn from sampling locations N4, N10, N14, N22, N23 during pre-monsoon season 2012) and 16% (Inference drawn from sampling locations N10, N21, N22, N23 during post-monsoon season 2012) of the groundwater samples had magnesium hazard value >50 and were unsuitable for irrigation purposes [22].

The graphical manifestation of the statistical summary for magnesium hazard of groundwater samples is presented in Figures 5 (i, ii and iii). The curves for magnesium hazard in these figures are positively skewed (0.448, 0.46 and 0.187) indicating spatial variation of magnesium hazard for the groundwater samples within the study area. The figures show that the curves are platykurtic or the values of the coefficient of fourth standardized moment $\beta_2 < 3$. The statistical summary for average magnesium hazard values of groundwater samples is also presented in Figure 5(iv) and shows the distribution to be platykurtic.

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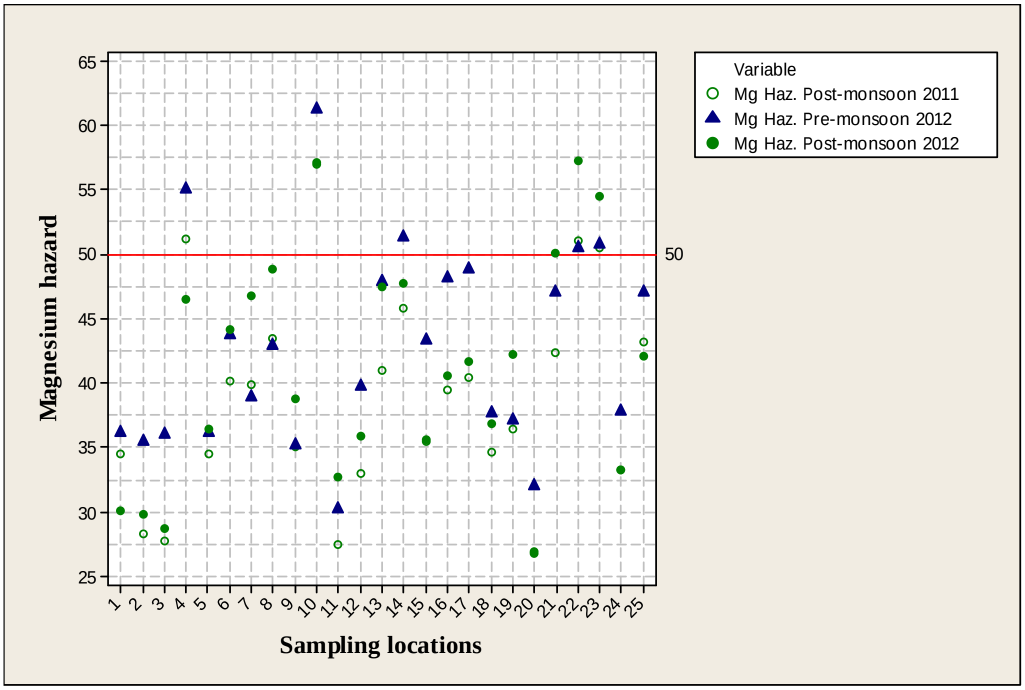

Fig. 1 Variation of magnesium hazard values of groundwater at sampling locations of Nalagarh industrial area

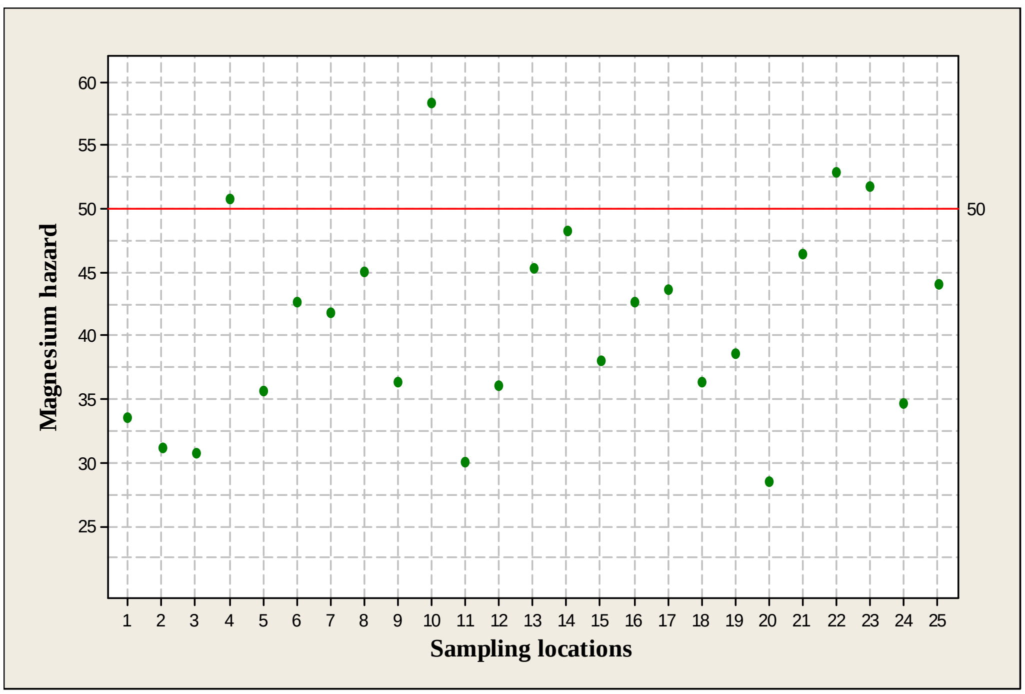

Fig. 2 Variation of average %Na values of groundwater at sampling locations of Nalagarh industrial area

One red coloured horizontal line has been drawn on the Figures 1 and 2 show the suitability of quality of groundwater for irrigation purposes.

Student's t-test reveals that there are no significant differences between the mean magnesium hazard values of:

1) Post-monsoon season 2011 and pre-monsoon season 2012 (t=1.752, p>0.05)
2) Pre-monsoon season 2012 and post-monsoon season 2012 (t=0.658, p>0.05)
3) Post-monsoon season 2011 and post-monsoon season 2012 (t=0.997, p>0.05)

B. Magnesium Hazard (Mg haz.)of Baddi Industrial Area

The magnesium hazard of the groundwater samples of industrial area of Baddi varied from a minimum value of 23.397 at sampling location B20 to a maximum value of 61.329 at sampling location B7 during post-monsoon season 2011, minimum 24.768 at sampling location B18 to maximum 64.478 at sampling location B7 during pre-monsoon season 2012 and minimum 19.958 at sampling location B18 to maximum 57.516 at sampling location B7 during post-monsoon season 2012. All the observations have been presented in Figures 3 and 6 (i, ii and iii). The average values of magnesium hazard (at individual sampling locations) varied from a minimum value of 23.172 at sampling location B18 to a maximum value of 61.107 at sampling location B7 (Figures 4 and 6iv). The average values of magnesium hazard (average of all the 40 samples) were found to be 40.96±9.144, 42.252±10.286, and 39.055±9.696 during post-monsoon season 2011, pre-monsoon season 2012, and post-monsoon season 2012, respectively thus accounting for an overall average magnesium hazard value of the groundwater samples of industrial area of Baddi as 40.756±9.252 (Figure 6iv). The results indicate that 12.5, 20 and 17.5% groundwater samples have magnesium hazard value > 50 during post-monsoon season 2011, pre-monsoon season 2012 and post-monsoon season 2012 respectively and were unsuitable for irrigation purposes [22].

The graphical presentation of the statistical summary for magnesium hazard of groundwater samples is presented in Figures 6 (i, ii and iii). While the curve for magnesium hazard in Figure 6(i) is negatively skewed (-0.109), Figures 6 (ii and iii) are positively skewed (0.088 and 0.173) indicating spatial variation of magnesium hazard for the groundwater samples within the study area. The figures indicate that the curves are platykurtic or the values of the coefficient of fourth standardized moment $\beta 2 < 3$. The graphical presentation of the statistical summary for average magnesium hazard values of groundwater samples is also presented in Figure 6(iv) and the distribution is found to be platykurtic.

Student's t-test reveals that there are no significant differences between the mean magnesium hazard values of:

1) Post-monsoon season 2011 and pre-monsoon season 2012 (t=0.594, p>0.05)
2) Pre-monsoon season 2012 and post-monsoon season 2012 (t=1.43, p>0.05)
3) Post-monsoon season 2011 and post-monsoon season 2012 (t=0.904, p>0.05)

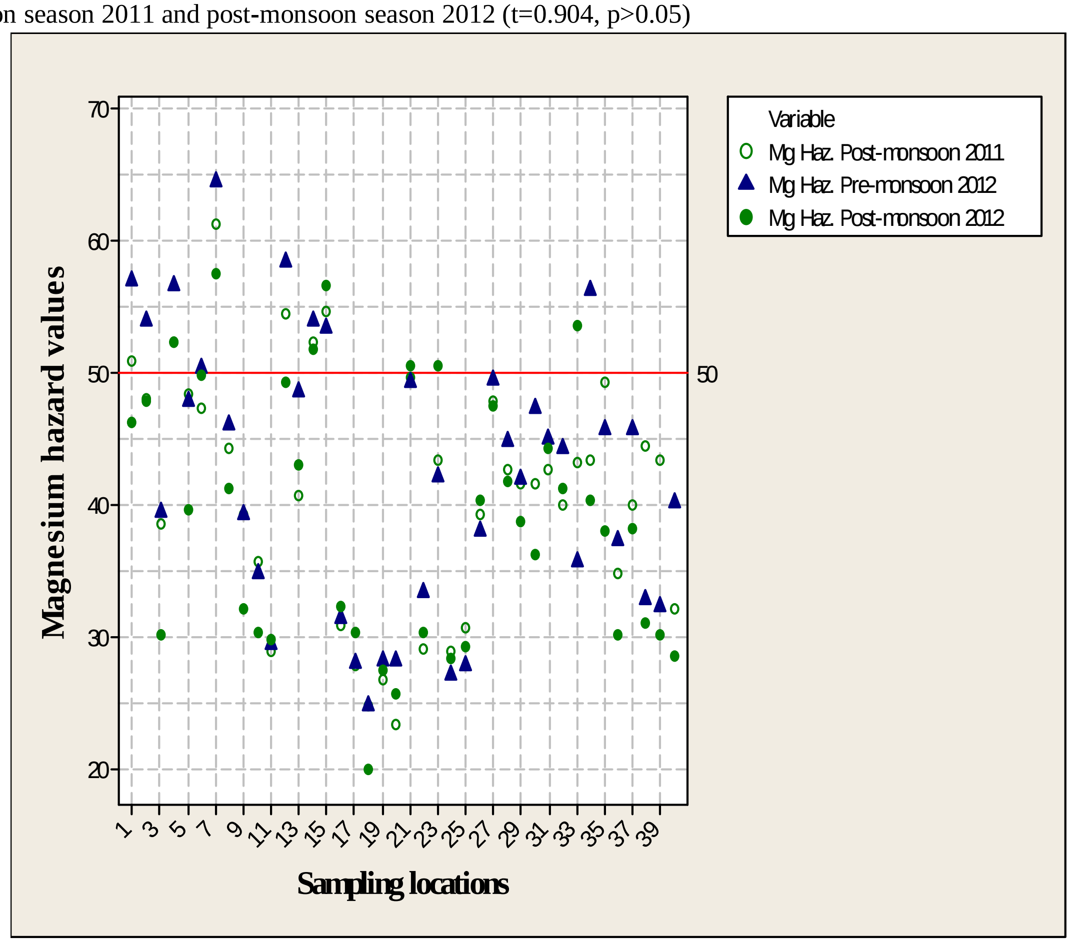

Fig. 3 Variation of magnesium hazard values of groundwater at sampling locations of Baddi industrial area

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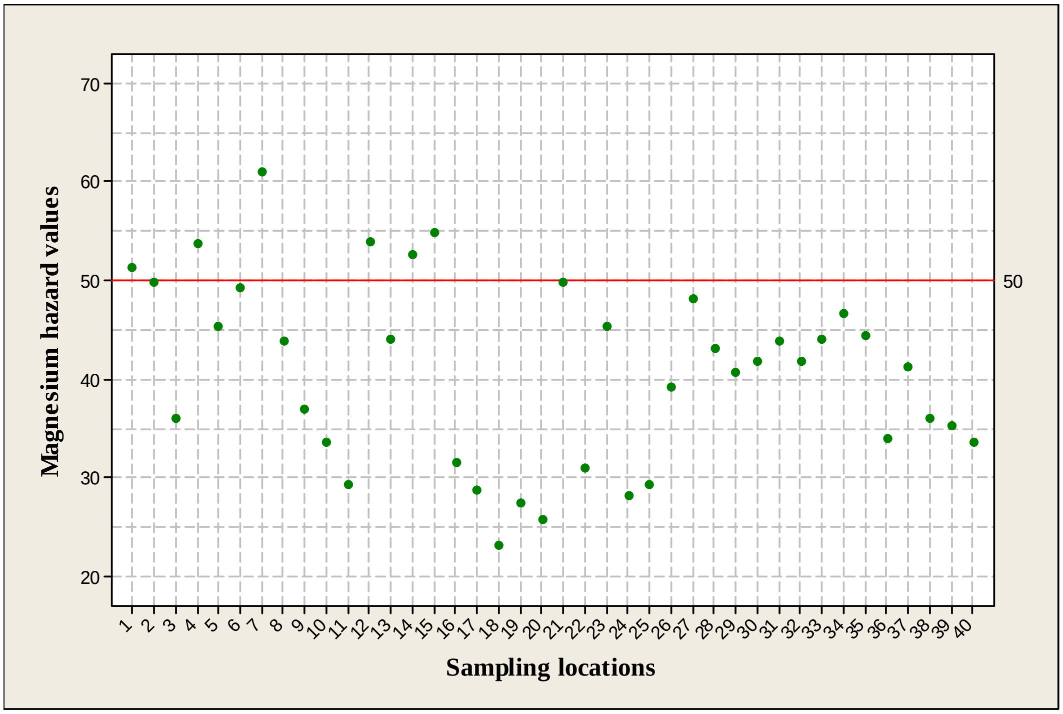

Fig. 4 Variation of average magnesium hazard values of groundwater at sampling locations of Baddi industrial area

One red coloured horizontal line has been drawn on the Figures 3 and 4 show the suitability of quality of groundwater for irrigation purposes.

IV. CONCLUSIONS

A. Significant conclusions derived from the study are:

1) At Nalagarh industrial area 16% (Considering the average values of all the seasons and inference drawn from sampling locations N4, N10, N22, N23), of the groundwater samples had magnesium hazard >50 and were found unsuitable for irrigation purposes. Since the overall average value (41.012±7.854) of magnesium hazard was found to be <50, hence suitable for irrigation.
2) At Baddi industrial area 15% (Considering the average values of all the seasons and inference drawn from sampling locations B1, B4, B7, B12, B14, B15), of groundwater samples had magnesium hazard > 50 and were found unsuitable for irrigation purposes. Since the overall average value (40.756±9.252) of magnesium hazard was found to be <50, hence suitable for irrigation.

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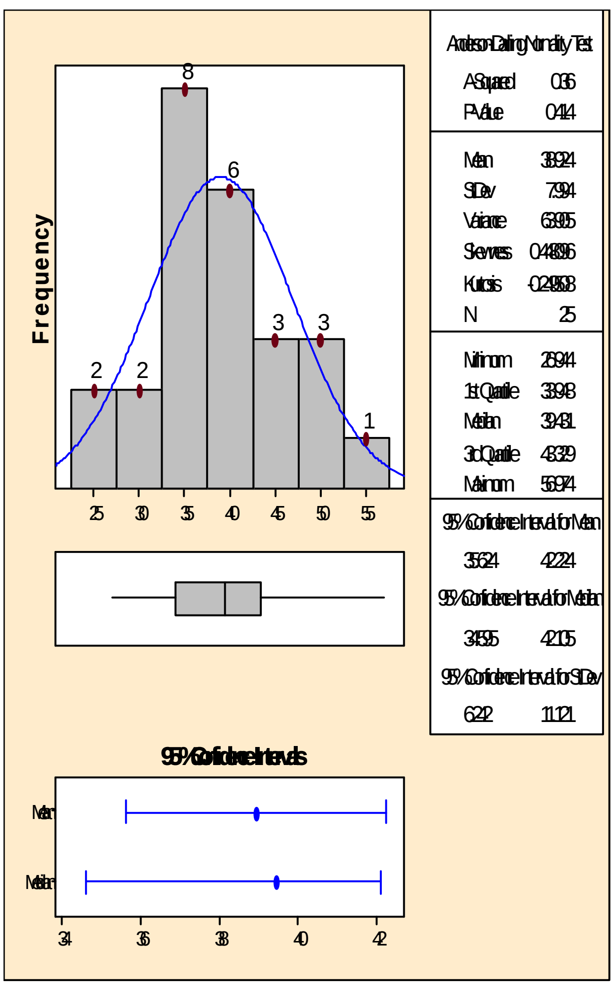
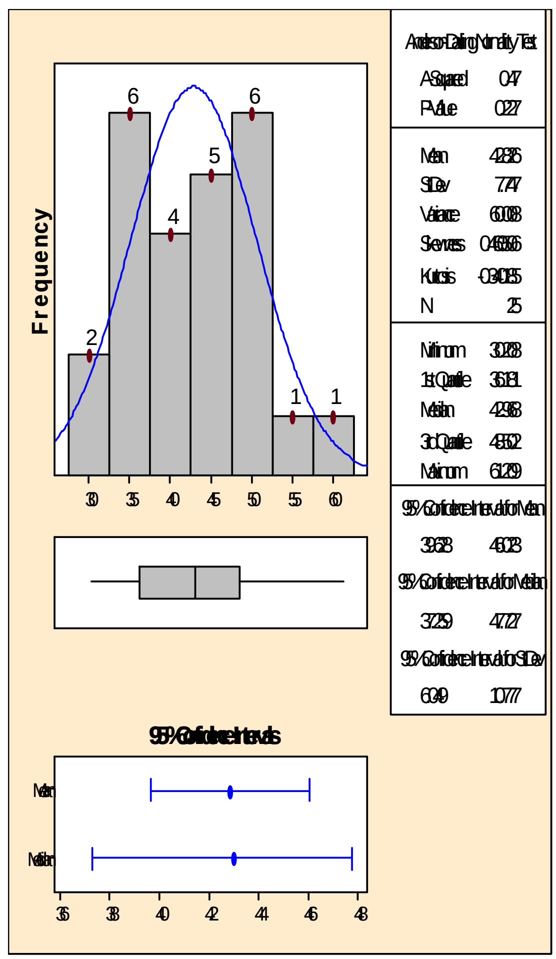
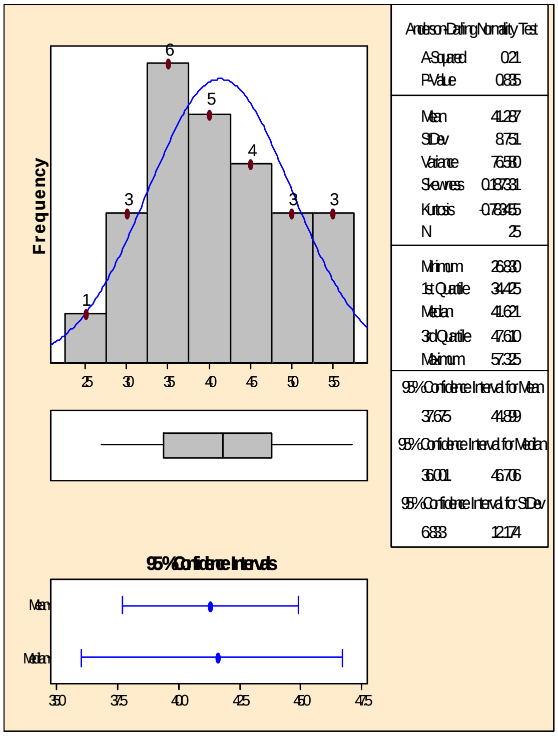


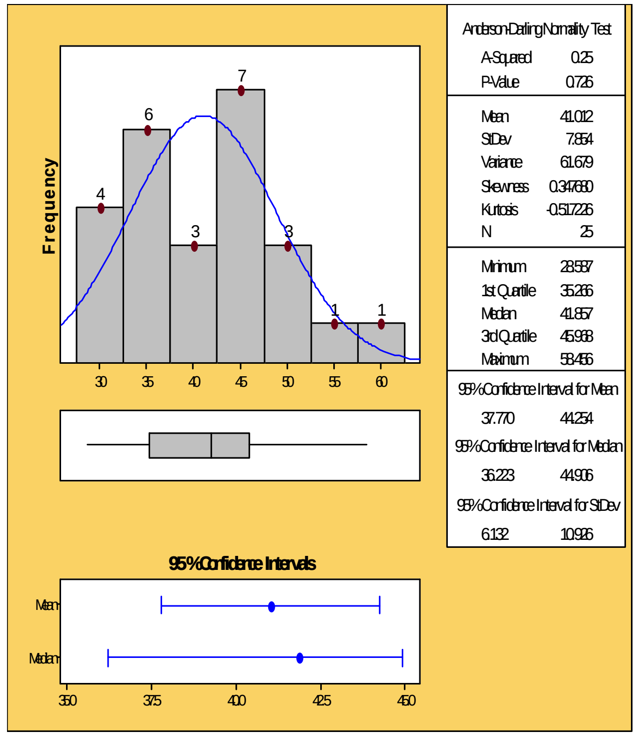


(ii) Pre-monsoon season 2012

(i) Post-monsoon season 2011

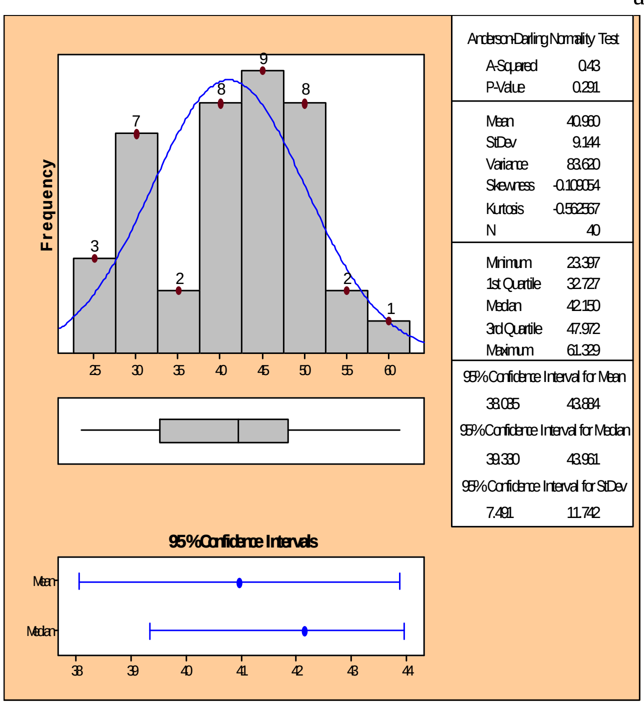


(iii) Post-monsoon season 2012

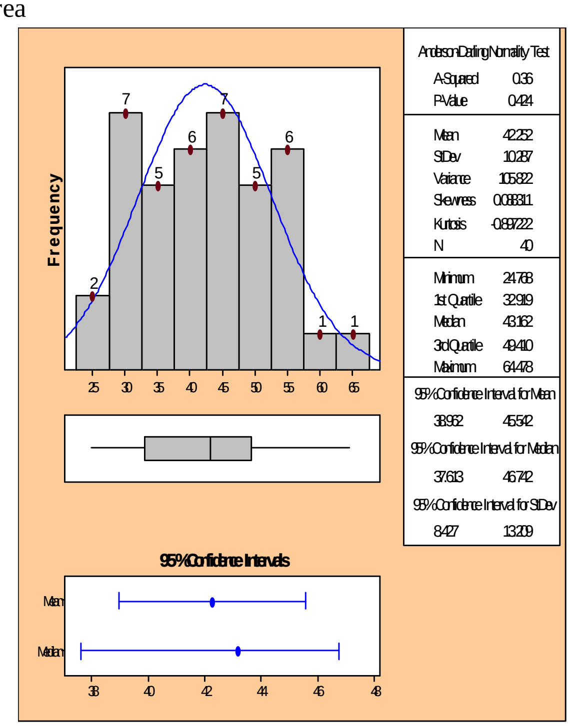


(iv) Average

Fig. 5 Graphical presentation of statistical summary for magnesium hazard (Mg haz.) of groundwater at Nalagarh industrial area



(i) Post-monsoon season 2011



(ii) Pre-monsoon season 2012

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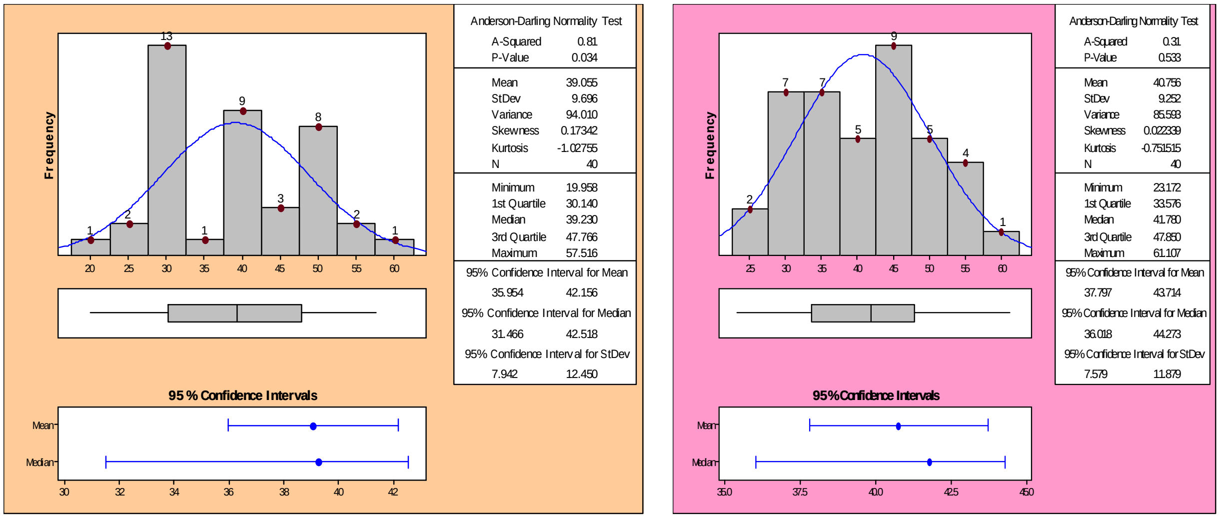

(iii) Post-monsoon season 2012 (iv) Average

Fig. 6 Graphical presentation of statistical summary for magnesium hazard (Mg haz.) of groundwater at Baddi industrial area