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Manganese: Affecting our Environment (Water, Soil and Vegetables)

Anjali
PG Student
Centre of Excellence for Energy and Environmental Studies, Energy Studies and Environmental Management
Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India

Jyoti Rani
Assistant Professor
Centre of Excellence for Energy and Environmental Studies, Energy Studies and Environmental Management
Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India

Anil Kumar
Lab Technician
Centre of Excellence for Energy and Environmental Studies, Energy Studies and Environmental Management
Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India

Abstract

Irrigation with untreated and treated industrial waste water, discharge of wastes from industries and the application of fertilizers and pesticides into the crop fields, have resulted the addition of heavy metals in the vegetables and soil. In the present study the level of manganese in water, soil and vegetable samples in Sonepat, Haryana (India) was analyzed using Atomic Absorption Spectrophotometer. The concentration of manganese in water, soil and vegetables were 0.06-0.502 mg/L, 107.15-214.90 mg/kg and 6.475-104.30 mg/kg respectively, while the WHO permissible limits were 0.2 mg/L, 500 mg/kg and 0.42-6.64 mg/kg respectively. Manganese concentration in Kundli water sample is found to be more than the maximum permissible limits, whereas the concentration of manganese in all soil samples is much higher than the WHO permissible limits. Manganese concentrations in the vegetable samples were within the maximum allowable limits. Moreover, soil pH is also evaluated and is found to be in the range of 6.92-7.9. As soil pH affects many chemical processes involved for plant growth.

Keywords: AAS, pH, soil, water, vegetables and MAL

I. INTRODUCTION

To transform our nation from developing to developed, scientists are introducing new technologies day by day. These technologies are modifying our living standards and adding contaminants into our environment. Due to rapid industrialization and urbanization, there is a shortage of fresh water available for other purposes. Also with increase in the population, the demand of food has also increased. As many industries are either disposing off their waste directly into the water streams or dumping it in the nearby land. Thus, they are adding contaminants in soil which is then can contaminate the crops grown on that soil or nearby area. There are many heavy metals reported in the literature (Mn, Pb, As etc.). The present study is concentrating on manganese.

Manganese is considered to be 12^{th} most abundant element in the biosphere. Its concentration in the earth's crust reaches as much as 0.098 mass%. It is widely distributed in soil, sediment, water and in biological materials. It can also affect the ecosystem negatively by accumulating in the food chain. Excess of manganese in drinking water can cause staining of kitchen utensils, bath accessories and clothes as well as yellowish water appearance, unpleasant taste and odor in food and drinks [1]. It is potentially hazardous not only to crop production, but also to human health through food consumption, ground water contamination and accumulation in food crops [2]. To some extent people can tolerate the contents of manganese present in their diet. However, what if the levels are much higher than that of the tolerable limits?

The present study is estimating manganese concentration in water used for irrigating the fields (i.e. tube well water), vegetables grown in that field and soil of the same field from which the samples were collected i.e. from 11 different sites of Sonepat district, Haryana (India) was assessed using Atomic Absorption Spectrophotometer which has been shown in fig.1.

II. MATERIALS AND METHODS

A. *Study Area*

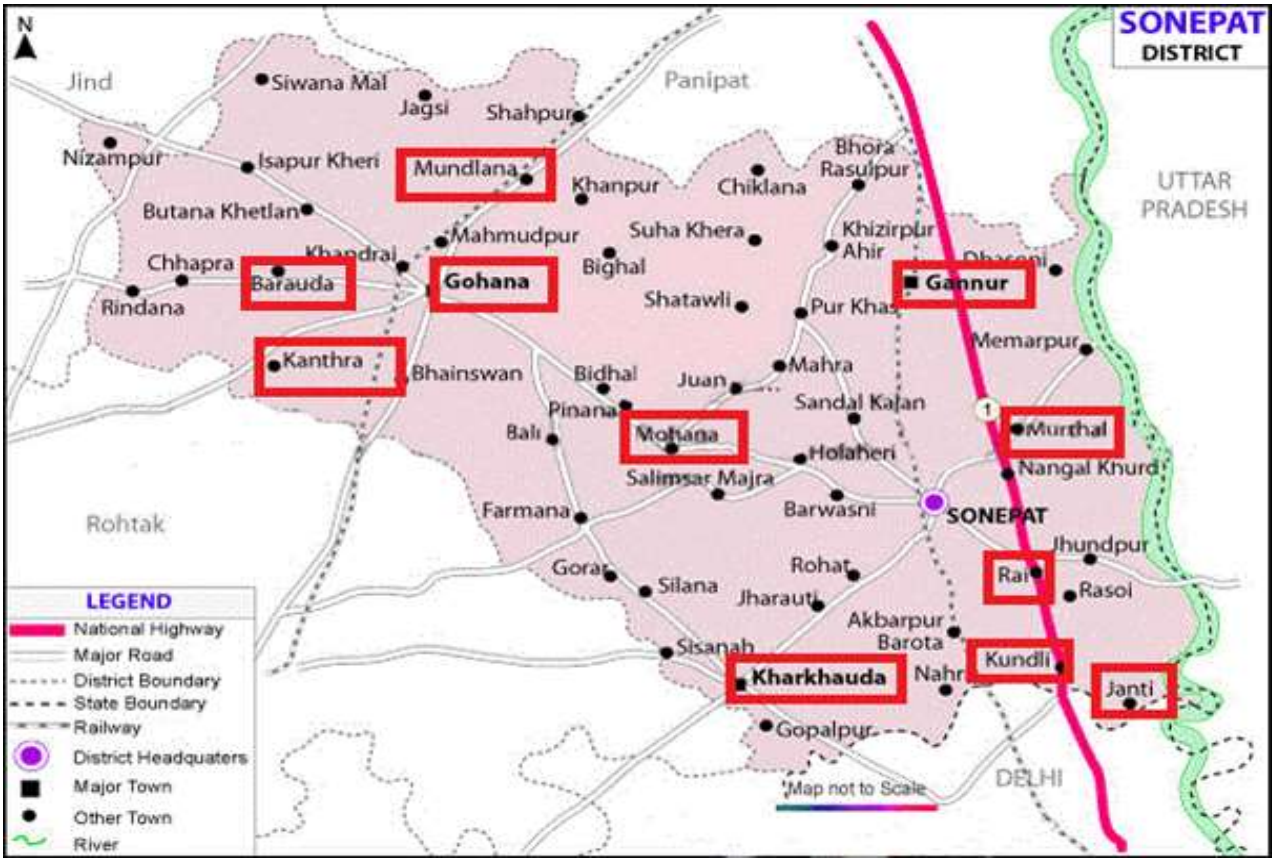


Fig. 1: Locations of Study Area

The total area of Sonepat district is 2260 sq.km and its population is 10, 64,000. Sonepat is bordered by the states of Delhi and Uttar Pradesh as well as the districts of Rohtak, Jind and Panipat. The river Yamuna runs along the eastern boundary of the district. District Sonepat comprises of 4 sub-divisions namely Gannur, Sonepat, Kharkhauda and Gohana. Sonepat is the largest tehsil followed by Gohana. It has one municipal corporation Sonepat and 3 municipal committees Gannur, Gohana and Kharkhauda.

Main water system in the district comprises of river Yamuna and the irrigation canals flowing out of it. There is no perennial river in the district. The ground water in some areas is saline and brackish. The ground water conditions indicate that the district faces the problem of occurrence of brackish water and water logging in eastern parts of the district. 11 different sites were selected and sampling of water, soils and vegetables of the surrounding areas were carried out to estimate the concentration of manganese.

B. *Water, Soil and Vegetable Sampling and Analysis*

Water, soil and vegetables samples were collected from 11 different locations as indicated in the Fig.1. Samples of different kinds of vegetables: leafy vegetables (Spinach and Cabbage), Inflorescence vegetables (Cauliflower), fruit vegetables (Lady's Finger, Brinjal, Tomato, kakri, bottle guard, tinda, kheera, touri) and root vegetable (onion) were taken in the analysis.

1) *Sample Collection*

Water samples collected from the tube well used for agricultural irrigation. The water samples were stored in polyethylene bottles, pre-washed with nitric acid and then 4ml of nitric acid was added to 100ml of water sample as a preservative [3].

For soil and vegetable sample collection, the field was digged from the four corners and the center up to a depth of 20cm and then the soil was collected and stored in plastic bags (zip-lock bags). After that samples were kept for sun drying for two days and then it was filtered through 2mm sieve. In case of vegetable samples after sun drying samples were first ground in mixer grinder to form a fine powder and then it was filtered by 2mm sieve. Only edible parts of different vegetables were taken from each site. All samples were labeled and taken to the laboratory for analysis. Vegetable samples were washed before analysis [5].

2) *Digestion Procedure*

Water samples were directly used for analysis. A working solution of sulphuric acid (65%), perchloric acid (70%) and nitric acid (70%) with ratio 1:1:5 was prepared and used for digestion of samples.

1g of dry powder of each vegetable/soil sample was digested in 100ml glass beaker by adding 15ml of afore mentioned three-acid mixture. Then the solution is heated at 80°C for 2 hours. After cooling down of the solution, it is filtered through whatman number 42 filter paper and filtrate was diluted to 100 ml with distilled water in case of soil samples and 50 ml in case of vegetable sample and then kept in plastic container for analysis [5].

Concentration of manganese in water and filtrate of digested soil and vegetable samples were estimated using an Atomic Absorption Spectrophotometer (AAS, Lab AA 7000). Acetylene gas was used as the fuel and air as the support. An oxidizing flame was used in all the cases.

3) Manganese Concentration Calculation

It is directly recorded from the instrument for the concentration of manganese in water (ppm or mg/L).

As the instrument provides values in ppm (mg/L) it is converted into mg/kg for vegetable and soil samples by using the following equation [3]

$$\text{Concentration (mg/kg)} = \frac{\text{concentration (mg/L)} \times V}{M}$$

Where,
V = Final volume of solution after digestion (mL)
M = initial weight of sample measured (mg)

Table - 1
Maximum Permissible Limits of Manganese According to Who Permissible Limits

S. No.	Substance	Limit
1.	Water	0.2 mg/L
2.	Soil	12 mg/kg
3.	Vegetables	500 mg/kg

III. RESULTS AND DISCUSSION

A. pH Value of Soil Samples

Soil pH is considered a master variable in soils as it affects many chemical processes. It specifically affects plant nutrient availability by controlling the chemical forms of the different nutrients and influencing the chemical reactions they undergo. The optimum pH range for most plants is between 5.5 and 7.5 [14]. Soil pH is fundamental to the understanding of soil systems, because it is an indicator of many reactions in the soils. It shows whether the soil is acidic, neutral or basic and provides useful information on the availabilities of the exchangeable cations. Soil pH controls plant nutrient availability and microbial reaction in soils [23].

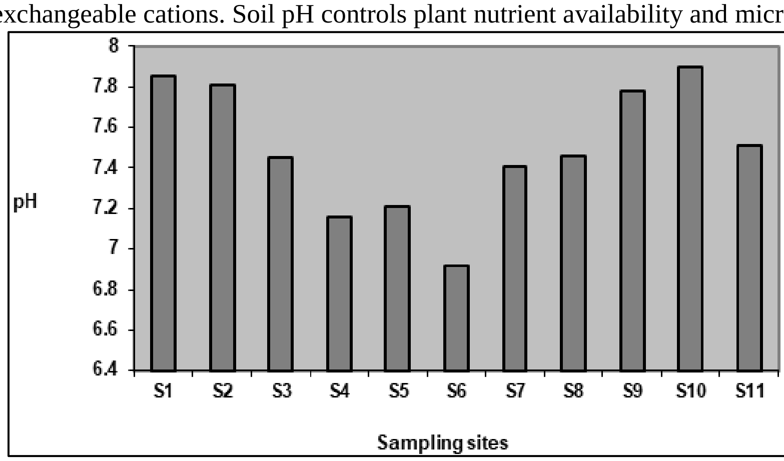


Fig. 2: pH Value of Soil Samples

In the present investigation the pH value is in the range of 6.92 to 7.9. Highest pH (7.9) value is found in Murthal. In the present study soil is found to be alkaline. The values are shown in Fig.2.

Similar results were found in Hyderabad, India found soil pH varies from 5.7-8.9 and is acidic to near neutral and alkaline in nature [17]. In Amritsar, Punjab it was found to be in the range of 7.4-7.8. Variation in pH values might be because of exposure of different soils to different types of pollutants [19]. In Narora, India it varied from 6.6-7.9 [20]. In Gujarat, India it is ranged from 6.5-8.3 [21]. In Assam, India it ranged from 4.48-5.62. Soil pH and high total organic matter content have a higher retention capacity of micronutrient metal in soil. Increase in pH in the soil results in increased micronutrient metal concentration in the soil. The higher pH favors the micronutrient retention in soil. The micronutrient uptake by plants decreases as the pH values increases [22]

The present results can be compared with the results of Faislabad, Pakistan (7.4-8) [20], Peshawar, Pakistan (7.81-8.80) [15] Iran (6.8-8.9) [11], Yola and Kano (7.6-9.5) [16], SE Congo-Brazzaville (5.69-6.25) and Nigeria (5.0-5.8) [23]. Other study carried out in Faislabad, Pakistan the soil pH ranged from 7.4-8. The pH was not problematic most probably due to regular addition of organic matter along with the sewage water [15] In Moanda, Gabon pH found to be 4.8±0.3. The decrease in pH in the surface layer may be due to use of chemical fertilizers, changes in particle size and a relative loss of soil organic mass [9]. In Makurdi, Benue State Nigeria the pH values ranged from 6.50-7.20 in the irrigated farmland soil samples. All the soils studied were either weakly acidic or neutral [25].

B. Level of Manganese in Water

The level of manganese in tube well water is found to be in the range of 0.003-0.251 mg/L. All the water samples were found to be within the WHO permissible limits except Kundli (0.251 mg/L). Similar results were found in Madhya Pradesh, India (0.001-0.375 mg/L) [4], Nagodi, Ghana (0.068-2.107 mg/L) [5] and Morocco (0.32-0.44 mg/L) [6]. Concentration of manganese at different sites in present study is represented in Fig.3.

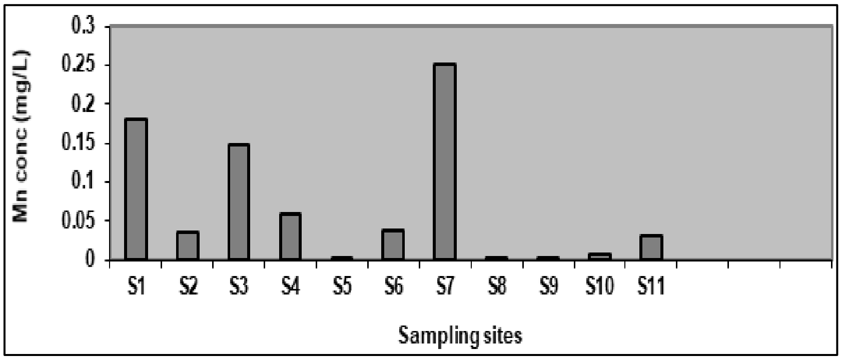


Fig. 3: Mn Concentration in Water Samples

Although the concentration of manganese in water sample are low. Yet, the continuous use of contaminated water may build the manganese concentration in soil as it has been already present in higher amount in soil. Some studies found more concentration of manganese than the present study. A study in Faislabad, Pakistan found manganese concentration in water is between 0.28-0.51 mg/L [7]. In Iran, the obtained results showed that in water samples, the concentration of manganese was 0.19-1.65 mg/L [8].

C. Level of Manganese in Soil

The concentration of manganese in soil is found to be in the range of 104.15 to 214.90 mg/kg. All these 11 samples were found having manganese concentration more than the WHO permissible limits.

Similar results were found in Rewa, Madhya Pradesh (44.52-66.08 mg/kg) [4], Narora, India (154-194), Lahore (9.12-30.08 mg/kg) [8], Morocco (85.67-88.91 mg/kg) [6] and Moanda, Gabon (<10,000 mg/kg) [9]. The values at different sites in present study are represented in Fig.4.

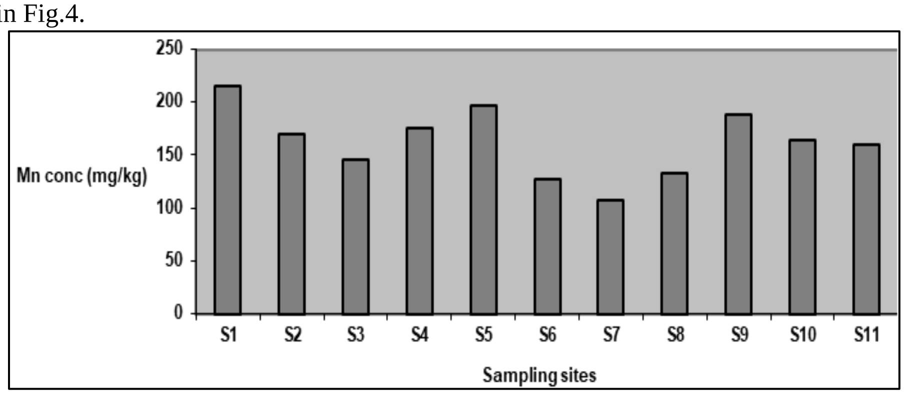


Fig. 4: Mn Concentration in Soil

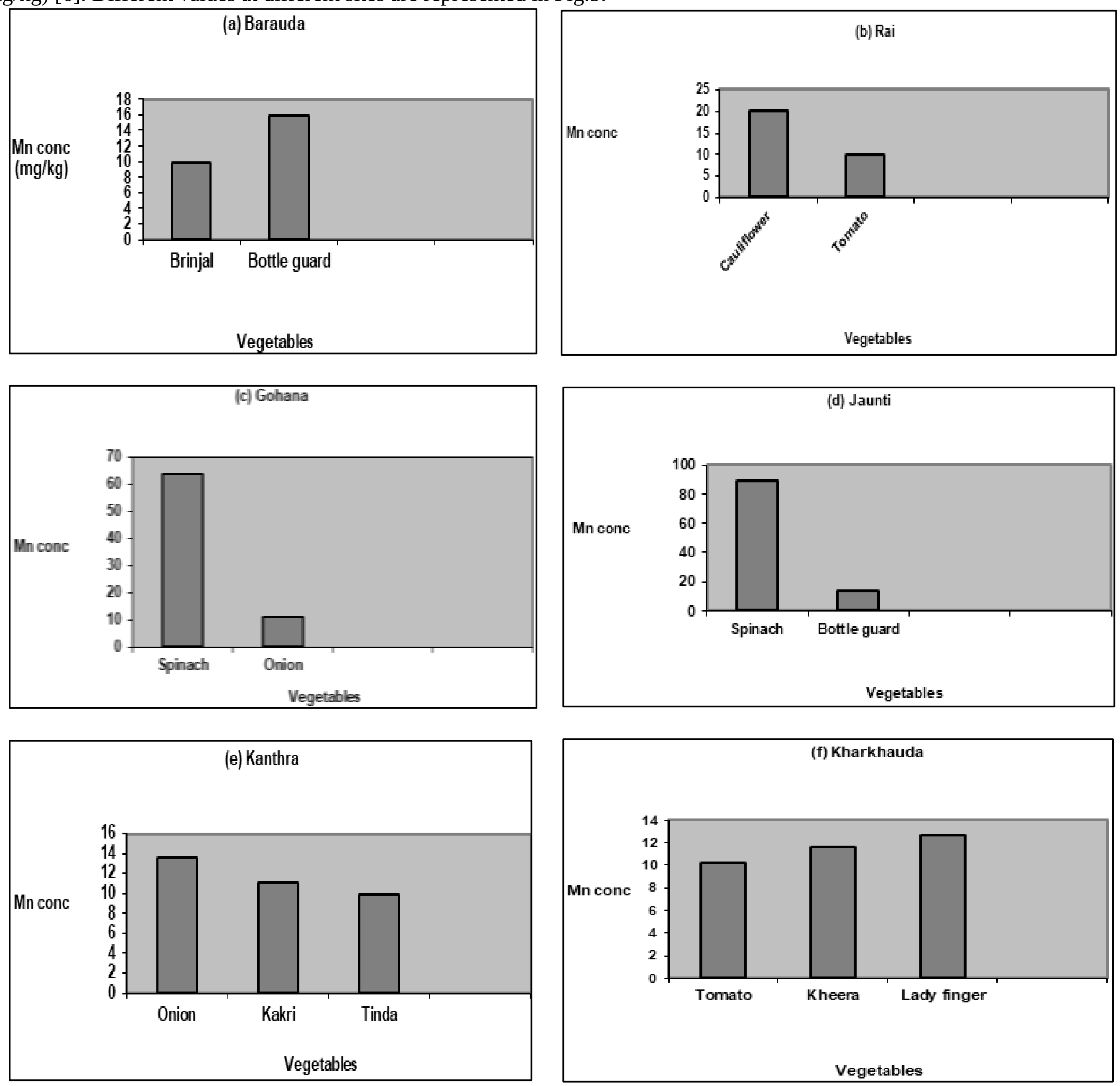
Higher concentration of manganese metal in soil does not mean that it will be bioavailable to plants as several factors like soil pH, conductivity etc. Manganese also acts as a micronutrient in soil and its lower concentration in edible part of the plant may cause health problems in animals and human beings.

Some other studies have found manganese concentration different from the present results. Manganese concentration was found to be in the range of 9.12-3.08 mg/kg in Lahore. It is due to the insolubility of metals because of high soil pH. Factors like soil pH, amount of organic matter, redox potential of soil and rate of addition of metals mainly affect their adsorption and retention in soil [8]. Another study in Guwahati, Assam, had manganese concentration in the range of 6.7-841.2 mg/kg. Enhanced concentration of manganese seems to be associated with high value of organic matter, pH and conductivity in soil. Atmospheric deposition of contaminated dust and industrial discharge may be the prime cause of manganese contamination in soil. The concentration of manganese to be appeared negatively correlated with organic matter and soil conductivity of the soil [10]. Another study in Iran showed the concentration is between 124-768 mg/kg. It is mainly of geological source, however anthropogenic activities related to use of fertilizers and sewage in agricultural lands may have led to increased amount of manganese in soil [11]. In south-east

Congo-Brazzaville, its concentration is found 6700 mg/kg. Trace metals concentration in the soil profile are higher than several times the permissible limits indicating an anthropogenic source. Trace metal concentration were found to decrease with increasing soil depth and pH [12]. In Moanda, Gaboon manganese concentrations in cultivated soils were greater than 10,000 mg/kg [9].

D. Level of Manganese in Vegetables

In the vegetable samples, manganese concentration ranges from 6.45 to 104.3 mg/kg. In the present study manganese concentration at different sampling sites are: Kanthra (9.875-13.625 mg/kg), Murthal (13.625-19.25 mg/kg), Barauda (9.875-15.95 mg/kg), Kundli (14.325 mg/kg), Rai (9.75-19.95 mg/kg), Mundlana (6.475-104.3 mg/kg), Jaunti (13.85-88.95 mg/kg), Gohana (11.15-63.75 mg/kg), Mohana (9.75-92.225 mg/kg), Kharkhauda (10.225-12.6 mg/kg) and Gannur (10.225-22.05 mg/kg). The maximum permissible limit for vegetables according to WHO/FAO (2007) permissible limits is 500 mg/kg. The present study concluded that the manganese concentration in all the vegetable samples were within the maximum permissible limits. Similar results were found in Faislabad (5.10-162.40 mg/kg) [7], Bulgaria (5.60-120.75 mg/kg) [13], Lahore (26.9-151.7 mg/kg) and Morocco (62.93-97.90 mg/kg) [6]. Different values at different sites are represented in Fig.5.



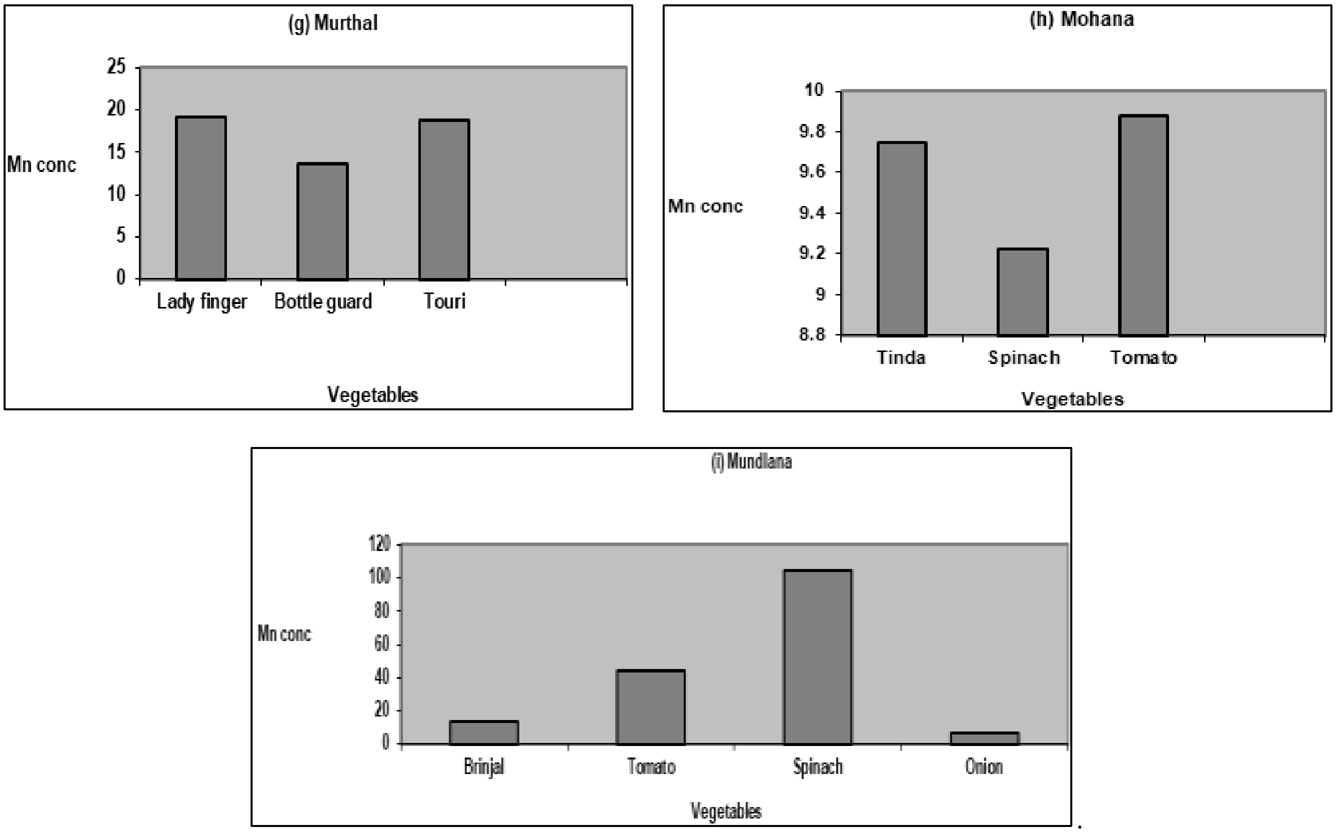


Fig. 5: Manganese concentration at different sites

Another study in Faislabad, Pakistan Manganese concentration in different parts of plants varied from 5.10-162.40 mg/kg [7]. In Nigeria, it ranges from 0.02-0.16 mg/kg. It is due to the peculiar type of agricultural practices in the area, such as the use of polluted water for growing of vegetables and the application of fertilizers and animal dung [3]. In Lahore, it ranged from 26.9-151.7 mg/kg. The uptake of manganese by vegetables is not only affected by plant species and physicochemical characteristics of soil but temperature and rainfall also exert substantial effect [8].

IV. Conclusion

In the present study, pH of soil samples was ranged from 6.92-7.9. Murthal was found to be having highest pH value. Soil is found to be alkaline in the study.

Manganese concentration in water except Kundli was found to be within the permissible range. In soil, it was found to be much higher the WHO permissible limits. So, growing vegetables in this soil may contaminate the food as well as the human health. But in vegetables, manganese concentration was found to be within the WHO permissible limits. Consumption of these vegetables as food may not constitute possible health hazards at the time of the study. These results may serve as a base line data for determination of manganese in vegetables in the area.

Although conditions are not very adverse but needs to be regulate the level of manganese in order to maintain the situation in control, routine monitoring and assessment of vegetables, soil and tube well should be done.

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