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Comparative Study of Macro-elements (P, Na and K) in the Edible Part of Vegetables Irrigated with Sewage, Canal and Tube Well Water

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The study was undertaken to compare the concentration of macro elements (P, Na and K) in edible part of the twelve different species of vegetables, irrigated with three different water sources. It was found that the accumulation of macro elements (P, Na and K) in the edible part of plants occurs in the order of: sewage > canal > tube well water.

Key Words: Macro elements, Edible part of vegetables, Quality of irrigation source.

INTRODUCTION

Irrigation is an artificial application of water to soil. It is used to assist the growth of agricultural crops, maintenance of landscapes and revegetation of disturbed soils in dry areas, during periods of inadequate rainfall and irrigation also include protecting plants against frost[1]. At global scale, 278.8 million hectares of agricultural land was equipped with irrigation infrastructure around the year 2000. About 68 % of the area equipped for irrigation is located in Asia, 17 % in America, 9 % in Europe, 5 % in Africa and 1 % in Oceania. One of the largest contiguous areas of high irrigation density is in North India and Pakistan along the rivers Ganges and Indus[2].

Vegetables are important protective food, highly beneficial for the maintenance of health and prevention of disease. Increasing fruit and vegetable consumption up to 600 g/day (baseline) could reduce the total worldwide burden of disease by 1.8 % and reduce the burden of ischaemic heart disease by 31 % and ischaemic stroke by 19 %. For stomach, oesophageal, lung and colorectal cancer, the potential reductions were 19, 20, 12 and 2 %, respectively[3]. Phosphorus is an essential nutrient for plants and animals. A well-fed adult consumes and excretes *ca.* 1-3 g of phosphorus per day[4] while an high intake of foods rich in natural and added phosphorus may raise the phosphorus and calcium ratio above 1:2, a value beyond which animal may have a risk of increased bone loss[5]. Sodium is an essential nutrient that regulates blood volume and blood pressure, while dietary salt increases cardiac left ventricular mass, arterial thickness and stiffness, the incidence of strokes and the severity of cardiac failure. High levels of dietary sodium (consumed as common salt, sodium chloride) are associated with raised blood pressure and adverse cardiovascular health[6,7]. Potassium ions are necessary for the function of all living cells, while high intake of potassium elevate concentration of the electrolyte potassium (K^+) in the blood, medically called hyperkalemia. Blood serum has potassium level less than 5.5 milliequivalents per liter. Any level over 6 mEq/L can be life-threatening, depending on the clinical setting[8-12].

EXPERIMENTAL

Samples were collected in the months of May and June 2010 from the different areas of Punjab, Pakistan. The collected samples were the edible part of the vegetables irrigated by canal, tube well and sewage water. All the samples were collected in paper bags with complete labeling of name, date and location, transferred to the laboratory. All the samples were collected in sunny days, temperature range 25-30 ºC.

General procedure: The vegetables with some soil and dust were washed with tap water first and then with distilled water. All the samples were primarily dried in open air covered with filter papers and further dried in an oven at temperature 70-80 ºC. All the dried samples were grinded in wooden mortar in such a way that mortar was cleaned thoroughly each time after use to avoid the intermixing of the samples. Sieving of the grinded samples was done in a stainless steel sieve of 5 mm mesh. The grinded samples were kept in air tight polythene bags labeled with sample number, in a dark and cool place[13,14].

The samples were digested by taking one gram of the dried sample in a 100 mL beaker and added 20 mL conc. HNO_3. The beaker was covered with a watch glass and allowed to

TABLE-1
CONCENTRATION OF MACRO-ELEMENTS (P, Na AND K) IN THE EDIBLE PART OF VEGETABLES IRRIGATED WITH SEWAGE, CANAL OR TUBE WELL WATER

Sample No.	Vegetable name	Botanical name	Location	P (mg/Kg)	Na (g/Kg)	K (g/Kg)
1CW	Lady's finger	*Hibiscus esculentis*	Kotli Arorha, Gujranwala	42	11.2	12.8
1SW	Lady's finger	*Hibiscus esculentis*	Francisabad, Gujranwala	44	10.2	13.4
1TW	Lady's finger	*Hibiscus esculentis*	Khawasra, Gujranwala	40	10.2	12.6
2CW	Mint	*Mentha Spicata*	Khawasra, Gujranwala	32	11.6	15.6
2SW	Mint	*Mentha Spicata*	Khiali bypass, Gujranwala	42	15.2	19.2
2TW	Mint	*Mentha Spicata*	Khawasra, Gujranwala	28	9.6	11.8
3CW	Coriander	*Coriandrum sativum*	Khawasra, Gujranwala	38	24.6	16.0
3SW	Coriander	*Coriandnum sativum*	Naroki, Gujranwala	40	26.2	24.6
3TW	Coriander	*Coriandnum sativum*	Muraliwala, Gujranwala	32	24.0	14.2
4CW	Bitter gourd	*Momordica charantia*	Kotli Arorha, Gujranwala	62	16.2	20.6
4SW	Bitter gourd	*Momordica charantia*	Francisabad, Gujranwala	60	20.4	26.6
4TW	Bitter gourd	*Momordica charantia*	Khawasra, Gujranwala	56	19.2	11.8
5CW	Bell pepper	*Capsicum annuum*	Jhan shah, Gujranwala	36	12.4	16.0
5SW	Bell pepper	*Capsicum annuum*	Naroki, Gujranwala	38	12.8	16.6
5TW	Bell pepper	*Capsicum annuum*	Muraliwala, Gujranwala	28	10.0	11.0
6CW	Green chillies	*Capsicum frutescens*	Khawasra, Gujranwala	30	16.2	13.8
6SW	Green chillies	*Capsicum frutescens*	Francisabad, Gujranwala	38	17.0	22.2
6TW	Green chillies	*Capsicum frutescens*	Khawasra, Gujranwala	30	14.2	15.6
7CW	Bath sponge	*Luffa Aegyptica*	Khawasra, Gujranwala	56	13.6	23.6
7SW	Bath sponge	*Luffa Aegyptica*	Francisabad, Gujranwala	64	17.2	29.4
7TW	Bath sponge	*Luffa Aegyptica*	Khawasra, Gujranwala	32	13.0	26.2
8CW	Tomato	*Solanum lycopersicum*	Jhan shah, Gujranwala	56	23.2	29.0
8SW	Tomato	*Solanum lycopersicum*	Khiali bypass, Gujranwala	62	24.6	33.4
8TW	Tomato	*Solanum lycopersicum*	Khawasra, Gujranwala	44	21.6	24.6
9CW	Vegetable marrow	*Cucurbita pepo*	Khawasra, Gujranwala	42	16.4	21.0
9SW	Vegetable marrow	*Cucurbita pepo*	Francisabad, Gujranwala	44	17.2	19.8
9TW	Vegetable marrow	*Cucurbita pepo*	Muraliwala, Gujranwala	40	16.4	20.8
10CW	Beans	*Vigna unguiculata*	Kotli Arorha, Gujranwala	44	9.8	8.2
10SW	Beans	*Vigna unguiculata*	Kohlowala, Gujranwala	52	10.8	8.8
10TW	Beans	*Vigna unguiculata*	Khawasra, Gujranwala	36	6.6	7.4
11CW	Onion	*Allium cepa*	Kotli Arorha, Gujranwala	34	7.4	4.4
11SW	Onion	*Allium cepa*	Mandiala mirshakara, Gujranwala	34	8.4	4.6
11TW	Onion	*Allium cepa*	Muraliwala, Gujranwala	30	5.8	4.2
12CW	Cucumber	*Cucumis sativus*	Kotli Arorha, Gujranwala	58	18.2	13.0
12SW	Cucumber	*Cucumis sativus*	Naroki, Gujranwala	76	20.0	13.6
12TW	Cucumber	*Cucumis sativus*	Muraliwala, Gujranwala	50	17.2	12.2

stand for 2 h. After that, the beaker was placed on a hot plate inside a fuming chamber until the solid particles nearly disappeared then removed from hot plate and was allowed to cool. After that 10 mL of 72 % $HClO_4$ was added and again placed on the hot plate. Heated gently first and then vigorously until solution in beaker became clear and volume reduced to *ca.* 5-6 mL then cooled and added 3 mL of 50 % HCl, again heated on hot plate until volume of the solution is reduced to 5 mL at the end it was allowed to cooled and added some distilled water.

The solution was transferred carefully to 100 mL measuring flask and made the volume up to mark, shacked well and allowed to stand overnight, filtered and collected in labeled plastic bottles. Bottles were preserved for the detection of macro elements. A blank test solution was also prepared by adopting the similar procedure without taking vegetable sample[15].

Detection method: Kitson and Milton's recommended method was adopted for detection of phosphorus and calculations were done by using the following formula[16].

$$\text{ppm of P in vegetable sample} = \frac{(S-B)\times V}{A\times W}$$

Sodium and potassium were detected by the recommended method of Thot and his coworkers while calculations were done by using the following formula[17].

$$\text{ppm of Na/K in vegetable sample} = \frac{(S-B)\times dt\times V}{W}$$

All the samples were tested on Flame Photometer PFP7 and spectrophotometer SP-1105.

RESULTS AND DISCUSSION

Phosphorus: The amount of phosphorus in ten vegetable species irrigated with sewage water was found higher (34-76 mg/kg) among all three types of samples. The amount of phosphorus in vegetables irrigated with canal and tube well water was 32-58 and 28-56 mg/kg, respectively. The highest amount of phosphorus was found 76 mg/kg in the cucumber (*Cucumis sativus*) grew near drain nala in village Naroki Gujranwala, totally irrigated with sewage water (industrial effluents and municipal drains). The amount of phosphorus was found equal in both samples of onion (*Allium cepa*) irrigated with sewage and canal water similarly in the green chillies (*Capsicum frutescens*) irrigated with canal and tube well water.

Sodium: The amount of sodium in 10 vegetable species irrigated with drain water was found higher (8.4-26.2 g/kg) among all three types of samples. The amount of sodium in the vegetables irrigated with canal water and tube well water was determined to be 7.4-24.6 and 5.8-24 g/kg, respectively. The highest amount of sodium was found 26.2 g/kg in the coriander (*Coriandrum sativum*) grew near drain nala in village Naroki Gujranwala, irrigated totally with sewage water.

The amount of sodium was found higher in bitter gourd (*Momordica charantia*) irrigated with tube well water than the bitter gourd (*Momordica charantia*) irrigated with canal water because those were grew in the field next to the poultry form. Lady's finger (*Hibiscus esculentis*) have same quantity of sodium irrigated with sewage and tube well water similarly Sodium was in same amount in the samples of vegetable marrow (*Cucurbita pepo*), irrigated with canal and tube well water.

Potassium: The amount of potassium in the edible part of vegetables was found higher (4.6-33.4 g/kg) in 10 vegetables species, irrigated with sewage water among all three types of samples. The amount of potassium in the vegetables irrigated with canal and tube well water was found in the range of 4.4-29.0 and 4.2-26.2 g/kg, respectively. The highest amount of potassium was determined in tomato (*Solanum lycopersicum*) 33.4 g/kg grew near vegetable market (Sabz mandi) Gujranwala irrigated with sewage water. The amount of potassium was found higher in green chillies (*Capsicum frutescens*) irrigated with tube well water than the green chillies (*Capsicum frutescens*) irrigated with canal water because those were grew in the field next to the poultry form. It was also noted that concentration of potassium was found lowest in the onion (*Allium cepa*) among all the vegetable samples.

Conclusion

Sewage water irrigation is practiced in various developing countries like Pakistan. This study shows that vegetables irrigated with sewage water come out from Gujranwala Punjab showed significant increase of macro elements (P, Na and K) in their edible parts and it is concluded that the concentration of macro elements (P, Na and K) in edible part of vegetables depend upon quality of water in irrigation source. The increasing order of macro elements (P, Na and K) was as under:

sewage > canal > tube well water

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