HEAVY METAL CONCENTRATIONS IN VEGETABLES WITH GROWTH STAGEAND PLANT SPECIES VARIATIONS

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Abstract: Vegetables constitute an important part of the human diet since there containcarbohydrates, proteins, as well as vitamins, minerals and heavy metals. Heavy metals are one of a range of important types of contaminants that can be found onthe surface and in the tissue of fresh vegetables (Bigdeli and Seilsepour, 2008). Anumber of elements, such as lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co),chromium (Cr), Copper (Cu) and Selenium (Se) (IV) can be harmful to plantsand humans even at quite low concentrations. Soil pollution iscaused by misuse of the soil, such as poor agricultural practices, disposal ofindustrial and urban wastes, etc.

The research was conducted in order to see the concentration of heavy metals in leafy vegetables spinach –*Spinaci aoleracea*, garlic - *Allium sativum* and onion - *Allium cepa*. Spinach, garlic and onion seeds were sown on 23rd November 2011; samples for analysis of these plants were taken at different stages –15, 30, 45 and 60 days after sowing.

Keywords: Vegetables, soil, heavy metals, concentrations, plant species, correlation coefficient.

INTRODICTION

The consumption of vegetables and fruits as food offer rapid and least means of providing adequate vitamins supplies, minerals and fibre. Vegetables are used as food include those used in making soups or served as integral parts of the main sources of a meal. Bach plants species has its nutritive requirements differing from others. Thus different plants supported by identical solutions will contain varying concentrations of minor and macro elements. Application of industrial effluent decreases the budding and growth rate of vegetables. Leafy vegetables occupy a very important place in the human diet, but unfortunately constitute a group of foods which contributes maximally to nitrate and other anions as well as heavy metals consumption. The excessive application of nitrogen and other inorganic fertilizers and organic manures to these vegetables can accumulate high levels of nitrate and other anions as well as heavy metals. And consequently their consumption by humans and animals can pose serious health hazards. Although some heavy metals such as Cu, Zn, Mn and Fe are essential in plant nutrition, many of them do not play any significant role in the plant physiology. The uptake of these heavy metals by plants especially leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health.

Vegetables constitute an important part of the human diet since there contain carbohydrates, proteins, as well as vitamins, minerals and heavy metals. Heavy metals are one of a range of important types of contaminants that can be found on the surface and in the tissue of fresh vegetables (Bigdeli and Seilsepour, 2008). A number of elements, such as lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), chromium (Cr), Copper (Cu) and Selenium (Se) (IV) can be harmful to plants and humans even at quite low concentrations (Bowen, 1979). Soil pollution is caused by misuse of the soil, such as poor agricultural practices, disposal of industrial and urban wastes, etc. (Buchaver, 1973). Soil is also polluted through application of chemical fertilizers (like phosphate and Zn fertilizers), and herbicides (Demi˙rezen and Aksoy, 2004). Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality, crop growth (Ma *et al*., 1994; Msaky and Calvert, 1990; Fergusson, 1990) and environmental health.

Soil pollution by heavy metals is great concern to public health (Goyer, 1996).The source of heavy metal in plant is the environment in which they grow andtheir growth medium (soil) from which heavy metals are taken up by roots or foliage of plants (Okonkwo *et al.*, 2005). Plants grown in polluted environmentcan accumulate heavy metals at high concentration causing serious risk to humanhealth when consumed. Moreover, heavy metals are toxic because they tend to bioaccumulation in plants and animals, bioconcentrate in the food chain and attack specific organs in the body (Akinola*et al.,* 2006; Chatterjee and Chatterjee,2000).

Plant species have a variety of capacities in removing and accumulating heavy metals. So there are reports indicating that some plant species may accumulate specific heavy metals (Markert, 1993). The uptake of metals from the soil depends on different factors, such as their soluble content in it, soil pH, plant species, fertilizers, and soil type (Lubben and Sauerberck, 1991). Vegetables, especially leafy vegetables, accumulate higher amounts of heavy metals (SharmaandKansal, 1986). Roots and leaves of herbaceous plants retain higher concentration of heavy metal than stems and fruits (Yargholi and Azimi, 2008). There are limited studies on heavy metal content at different growth stages of vegetables, the most studies focused on the status of metal content in edible parts of vegetables. And an investigation of the literature also shows a scarcity of data on comparison of metal content at different leafy vegetable species. Therefore, the present study was undertaken to compare and investigate the concentration levels of heavy metals (Pb, Cd, Ni, Co, and Cr) at different growth stages of the commonly grown leafy vegetables; to find out a growth stage, which stage is less content of heavy metals;) to quantify the concentrations of heavy metal content by different vegetable species.

PLANT AND SOIL SAMPLE COLLECTION

Plant and soil samples were collected at four growth stages of vegetables at 20, 30, 40, and 50 days after sowing. The samples were collected carefully using hand trowel to dig the soil around the plant and the plants were pulled out carefully, ensuring that no part of the root was lost. Plant samples were kept in separate polythene bags and properly labeled. Soil samples were collected at a depth of 0-15 cm from the same point of collecting plant samples. The samples were kept in polythene bags and labeled properly. The plant and soil samples were analyzed in the laboratory.

PREPARATION AND PRESERVATION

The vegetable samples were washed in fresh running water to eliminate dust, dirt, possible parasites or their eggs and then again washed with deionized water. Theclean vegetable samples were airdried and placed in an electric oven at 65 °C for72–96 h depending on the sample size. The dried vegetables samples were homogenized by grinding using a ceramic coated grinder used for metal analysis.

All soil samples were spread on plastic trays and allowed to dry at ambient temperature for 8 days. The dried samples of soils were ground with a ceramic coated grinder and sieved through a nylon sieve. The final samples were kept in labeled polypropylene containers at ambient temperature before analysis.

DIGESTION AND DETERMINATION

One gram of dry matter was weighed into 50-ml beaker, followed by the additionof 10 ml mixture of analytical grade acids HNO3: HClO4 in the ratio 3:1. Thedigestion was performed at a temperature of about 190 ºC for 1.5 h. After cooling, the solution was made up to a final volume (30 ml) with distilled waterin a volumetric flask. The metal (Pb, Cd, Ni, Co, and Cr) concentrations were determined by atomic absorption spectrometry using a PERCIN ELMER 5000. Analysis of each sample wascarried out three times to obtain representative results and the data reported in μg/g (on a dry matter basis).

RESULTS AND DISCUSSION

The consumption of vegetables and fruits as food offer rapid and least means of providing adequate vitamins supplies, minerals andfibre. Vegetables are used as food include those used in making soups or served as integral parts of the main sources of a meal. Bach plants species has its nutritive requirements differing from others. Thus different plants supported by identical solutions will contain varying concentrations of minor and macro elements. Application of industrial effluent decreases the budding and growth rate of vegetables. Leafy vegetables occupy a very important place in the human diet, but unfortunately constitute a group of foods which contributes maximally to nitrate and other anions as well as heavy metals consumption. The excessive application of nitrogen and other inorganic fertilizers and organic manures to these vegetables can accumulate high levels of nitrate and other anions as well as heavy metals. And consequently their consumption by humans and animals can pose serious health hazards. Although some heavy metals such as Cu, Zn, Mn and Fe are essential in plant nutrition, many of them do not play any significant role in the plant physiology.

The uptake of these heavy metals by plants especially leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health. Vegetables act as neutralizing agents for acidic substances formed during digestion. As human activities increases, especially with the application of modern technologies, pollution and contamination of the human food chain has become inevitable. The uptake of heavy metals by plants grown in polluted soils has been studied to a considerable extent. Heavy metal contamination in vegetables cannot be underestimated as these food stuffs are important components of human diet. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance. International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of the risk, these metals pose to food chain contamination. Rapid and unorganized industrialization and urbanization have contributed to the elevated levels of heavy metals in the urban environment in developing countries Heavy metals are non biodegradable and persistent environmental contaminants which may be deposited on the surfaces and then adsorbed into the tissues of the vegetables. Plants take-up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soils. Watercontamination by heavy metals in some areas is practically inevitable due to natural process (weathering of rocks) and anthropogenic activities (industrial, agricultural and domestic effluents). Waste water from the industries of mining, electroplating, paint or chemical laboratories often contains high concentrations of heavy metals, including Cadmium (Cd), Copper (Cu) and lead (Pb). These elements, at concentrations exceeding the physiological demand of vegetables, not only could administer toxic effect in them but also could enter food chains, get biomagnified and pose a potentialthreat to human health. Heavy metal contamination in agricultural soils from wastewater irrigation is ofserious concern due to its implications on human health. Vegetables can absorb metals from soil as well as from deposits on the parts of the vegetables exposed to the air from polluted environments.

The results (Table 1, table 2, Table 3, Table 4) showed that the concentration of lead, zinc, cadmium, nickel, and cobalt increased with increasing age of the plant. The percentage of increase of heavy metals was higher from 15th to 30th day, compared to that between 30th and 45th day.

The concentration of heavy metals gradually increases in the early stage of the plant growth, and gradually declines in later stages of growth. The significant differences ($P < 0.01$) were observed between the mean metal concentrations in the three vegetables species. Higher concentrations of lead and cadmium were found in spinach, compared to garlic and onion. The order of heavy metal level in different vegetables was Cd<Co<Pb<Ni<Cr. The value of the correlation coefficient soil-plant was highest for cadmium and lowest for nickel.

The result indicated that there was significant difference ($P < 0.01$) in mean heavy metal content in the three vegetable species. The result showed significantly higher level of Pb concentration in amaranth compared to spinach and red amaranth. Spinach exhibited significantly higher levels of Cd and Cr than the other vegetables.

Table 1: Mean values of Pb, Zn, Cd, Ni, Co, and Cr concentration of leafy *Spinacia oleracea* (μg/g)

Spinacia oleracea	*Pb*	*Zn*	*Cd*	*Ni*	*Cr*	*Cu*
15 days	*0.72*	*1.23*	*0.17*	*0.22*	*0.32*	*0.48*
30 days	*3.53*	*1.98*	*1.35*	*2.45*	*1.89*	*1.64*
45 days	*6.74*	*3.25*	*2.94*	*3.92*	*3.14*	*3.19*
60 days	*4.52*	*1.76*	*1.22*	*1.78*	*2.27*	*1.92*

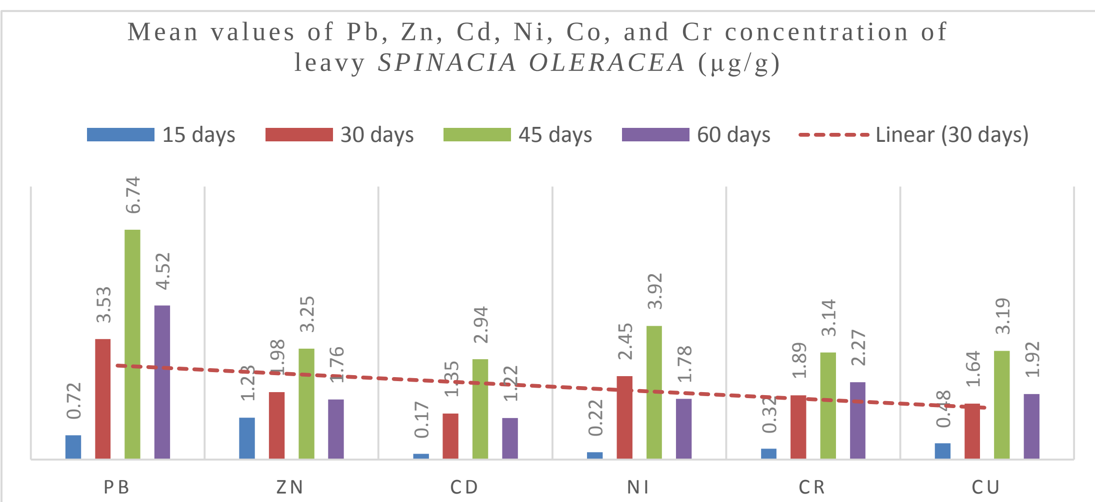

Table 2: Mean values of Pb, Zn, Cd, Ni, Co, and Cr concentration of leavy *Allium sativum* (µg/g)

Allium sativum	*Pb*	*Zn*	*Cd*	*Ni*	*Cr*	*Cu*
15 days	*0.63*	*1. 78*	*0.12*	*0.31*	*0.28*	*0.77*
30 days	*2.55*	*2.55*	*0.97*	*3.14*	*1.54*	*1.92*
45 days	*5.98*	*3.70*	*1.95*	*4.57*	*3.90*	*3.96*
60 days	*3.21*	*2.14*	*1.15*	*1.82*	*2.75*	*2.05*

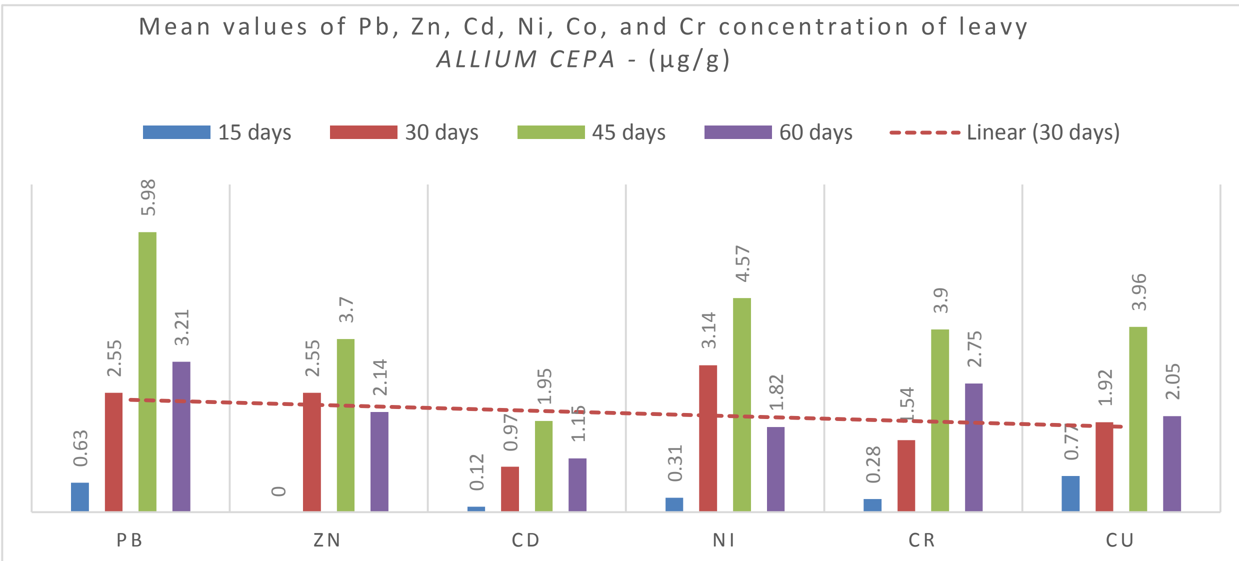

Table 3: Mean values of Pb, Zn, Cd, Ni, Co, and Cr concentration of leavy *Allium cepa* - (µg/g)

Allium cepa	*Pb*	*Zn*	*Cd*	*Ni*	*Cr*	*Cu*
15 days	*0.65*	*1.84*	*0.09*	*0.39*	*0.30*	*0.87*
30 days	*2.80*	*2.46*	*0.81*	*2.90*	*1.77*	*2.21*
45 days	*4.98*	*3.90*	*1.72*	*4.46*	*4.02*	*3.53*
60 days	*2.45*	*1.15*	*1.20*	*1.25*	*2.72*	*1.92*

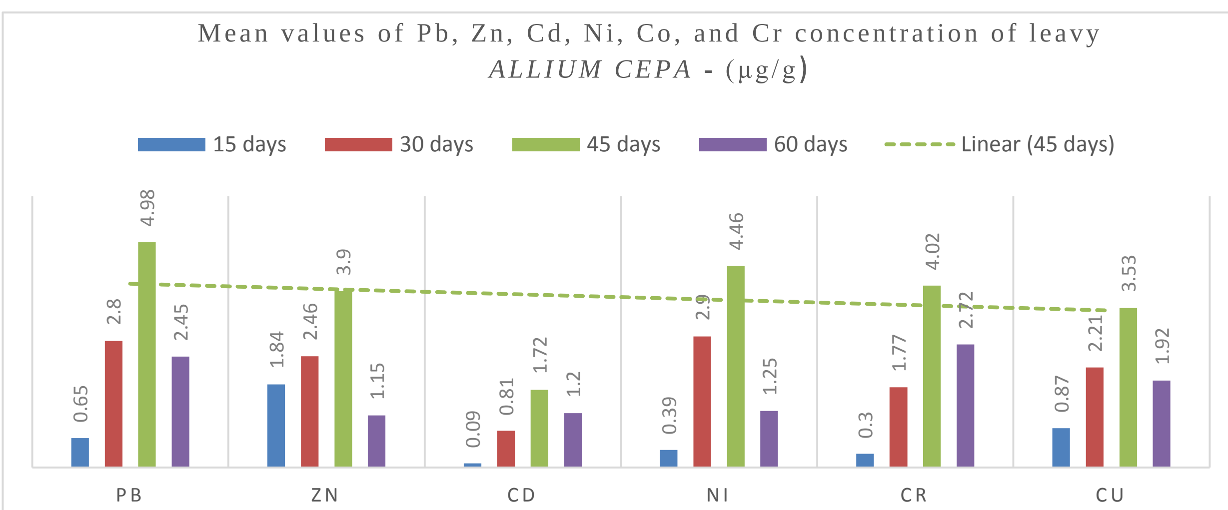

Table 4: Mean values of Pb, Cd, Ni, Co and Cr concentration of soils where the vegetables grown (µg/g)

Vegetable	*Pb*	*Zn*	*Cd*	*Ni*	*Co*	*Cr*
Spinacia oleracea	*5.27*	*3.78*	*0.90*	*13.26*	*13.66*	*24.19*
Allium sativum	*6.23*	*5.94*	*1.05*	*14.87*	*12.86*	*25.32*
Allium cepa	*7.12*	*5.32*	*1.22*	*16.25*	*14.43*	*22.90*

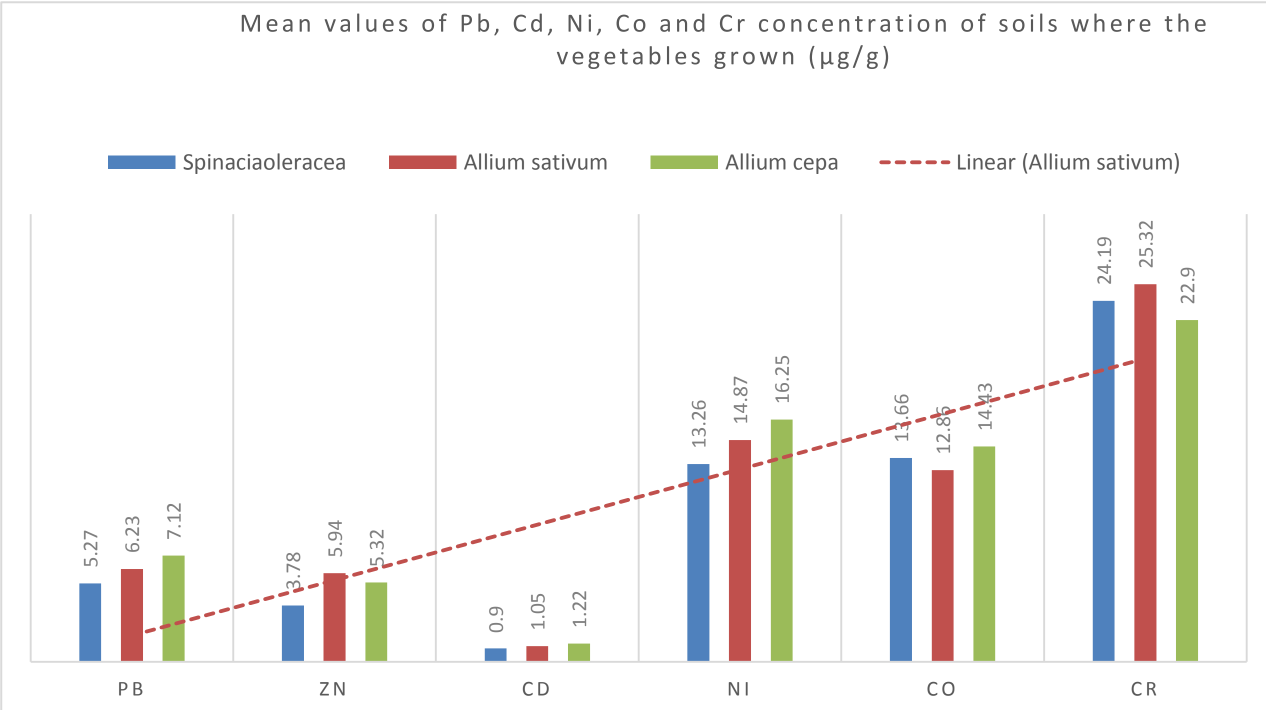

Table 5: Correlations between heavy metal content in soils and in vegetables (µg/g, *=*p* <0.05, **=*p* <0.01, ns=non significant)

Vegetable	*Pb*	*Zn*	*Cd*	*Ni*	*Co*	*Cr*
Spinacia oleracea	*0.944*	*0.92*	*0.94*	*0.71*	*0.91*	*0.89*
Allium sativum	*0.90*	*0.95*	*0.92*	*0.69*	*0.65*	*0.94*
Allium cepa	*0.87*	*0.93*	*0.98*	*0.82*	*0.72*	*0.72*

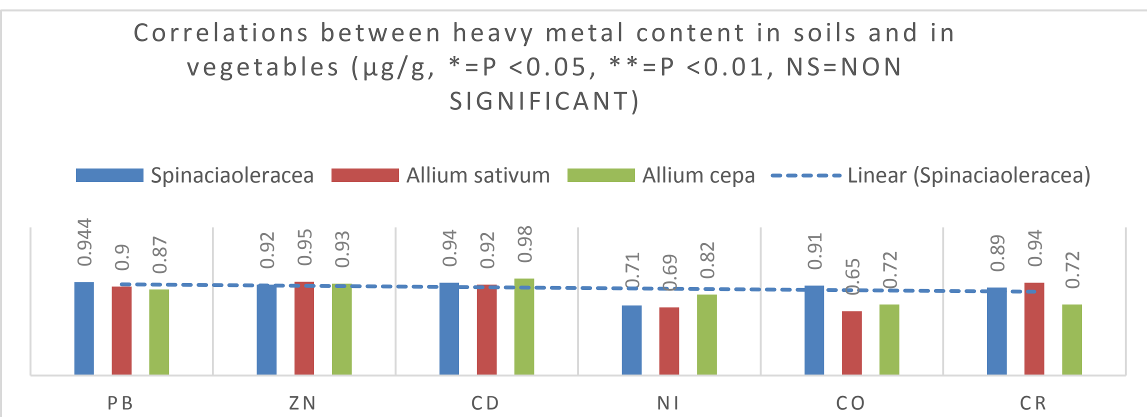

Table 4. Transfer factor (±, standard deviation) of Pb, Zn, Cd, Ni, Co and Crfor the soils to vegetables species.

Vegetable	*Pb*	*Zn*	*Cd*	*Ni*	*Co*	*Cr*
Spinacia oleracea	0.322±0.014	*0.265*±0.012	0.783±0.016	0.338±0.007	0.093±0.003	0.312±0.006
Allium sativum	0.314±0.012	*0.231*±0.010	0.462±0.010	0.351±0.023	0.125±0.005	0.279±0.003
Allium cepa	0.325±0.005	*0.314*±0.008	0.731±0.019	0.346±0.017	0.134±0.003	0.296±0.00Z

CONCLUSIONS

Heavy metal content in different leafy vegetables varies significantly. The content varies with time of harvesting and stage of maturity of crops. The Cd and Cr contents in leafy vegetables in this study were detected higher while Pb and Ni were within the permissible limits as per the WHO standard but all the metals were within the maximum allowable level. The magnitude of time dependence of plant metal concentration variations differed among crop species and metals. Further research is needed to obtain more specific information about the effect of age of the plants on accumulation and distribution of the heavy metal in the different plant parts, variations in uptake between different plant species, cropping history and fertilization.

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