The present work was undertaken to study the pattern of various electrolyte and important component of food viz. carbohydrate, protein and fat with other micronutrient in relation to serum electrolytes, value of these component in the individuals and the pattern of urinary excretion in the different geographical environment at the extreme of temperature variation amongst the residents of the North east hill area of Mizoram (Aizawl) and Gangetic plain of Uttar Pradesh (Varanasi). Total 400 individuals were subjected for the above study, of which 200 each from Aizawl and Varanasi from the study group.

There were younger people from the Aizawl group (71%) between the age group of 20-40, whereas in Varanasi majority of the individuals belonged above 40 years (45%). At both of the sites male dominated, however in Aizawl (Male 62%, Female 38%) there were more female individual than Varanasi (Male 73%, Female 27%). This could be a reflection of difference in the cultural background, where in Aizawl female contribute significantly in supporting the family as an earning member than the plain where male members are the principle bread earner. Amongst all individuals who participated in the present study, there were more white collar job seekers from Aizawl (83%) than Varanasi (67%). In the plain area of Varanasi there are more industrial and agricultural based job opportunities, which demand more manual workers than the hill area and this fact has been reflected in the
present study. Non-vegetarian diet consumers were higher in proportion (81%) in Aizawl than in Varanasi (59%). However overall there has been tendency towards non-vegetarian diet at both of the site due to fast industrialization of the out skirts of the metro cities as well as urbanization of the rural areas, both has changed the dietary pattern of the individuals, the pattern has also been affected by relaxation in the cultural values where eggs are no more considered as non-vegetarian food. Nevertheless individuals living at the high hill areas covered with deep forests have easy access to non-vegetarian food because of the scarcity of farming land and the nature of the soil. Furthermore uneven rocky mountain and terrains further limits the possibility of easy cultivation and transport of the food material than the plain area, where the accessibility of the resources is much easy.

In the last millennium the body mass index has become one of the important epidemiological factors in health and diseases and is also directly correlated with various ethnic and tribal populations with their environmental factors. In our study, we observed higher body mass index in all the age group from the Varanasi than the individuals from Aizawl and the value were highly significant ($p<0.001$) in the age group of 20-40 (Table no. 5.1). At both the sites female had higher body mass index, but this was statistically nonsignificant. However male individuals had significant ($p<0.001$) body mass index in plain area of the Varanasi than Aizawl (Table no. 5.6). This pattern reflected equally, when the body mass index was compared with work place in which at both sites white collar individuals had higher body mass index than blue collar subjects and both data were statistically highly significant ($p<0.001$) (Table no. 5.7). This study is well comparable to Australian study where white collar male had higher body mass index than blue collar male and the pattern was reversed in the female workers (Allman-Farinelli et al 2010).
In an Indian study from North-east tribal group by Khongsdier (2001) lower body mass index was observed (20.49 ± 1.13 and 19.85 ± 1.46), whereas another study from Jalandhar (Punjab) by Koley et al (2009) demonstrated higher body mass index amongst housewives (24.82 ± 4.45) than the laborers. Both of the above studies confirm our observation that white collar workers have higher body mass index and also people from tribal areas of Assam and Meghalay (Khongsdier 2001) have similar body mass index as the Aizawl residents, while individuals fromVaranasi are well comparable with the residents of Punjab who had significantly higher body mass index (Koley et al 2009). The individuals from the Aizawl did not show so much difference between body mass index and dietary pattern, however at the site of Varanasi, vegetarians were found to have relatively higher body mass index. In a study from PUDUE university vegetarians had low body mass index than the non-vegetarian with low blood pressure and similar observation was also made in Mexico, China and UK (Christopher et al (1989), Wyatt et al (1995), Woo et al (1998) and Appleby et al (1998). In a Swedish study in 2002, vegetarians were found to have low body mass index and also low blood pressure (Larrson and Johansson 2002). No such study from the Indian continent has been reported, where body mass index has been considered with the dietary pattern. The difference in our study may be due to relatively higher carbohydrate intake amongst residents of Varanasi, who were also white collar workers and had less opportunity of physical exercise, which could shape their body mass index. When age was correlated with body mass index pattern in Aizawl, younger age group showed a lower body mass index (p=<0.001) than the Varanasi, where the older age had higher body mass index but this was statistically nonsignificant (Table no. 5.9).

Salt and electrolytes have been established as an important constituent of the human blood in regulating the blood pressure and urinary excretion in
different environmental factors. This quality was acquired by animals millions of
year before when life took its evolution in the great ocean and the cell developed
the property of diffusion through its cell membrane for extra sodium back to
ocean and to maintain intracellular environment in an osmotic state to keep
the nucleus and other cytoplasmic contents in a viable state. As the animal
became complex, it developed a system of excretion by which the diffusion
process can be regulated through skin and urinary system (Natochin 2007).

The movement of animal from sea to terrestrial plain further made the
excretory system in able to conserve the water as well as salt depending upon
change in humidity and ambient temperature as well as the type of food
which was consumed by the individual animals. In human beings this quality
is maintained by kidney and by process of sweating through exposed body
surface area in accordance with the variation of humidity and temperature.
The adaptive response to these variables depends upon the perfusion of the
kidney, which is regulated by systemic blood pressure. Thus study of blood
pressure is important physical parameter in the adaptation of the human
being during extreme variation of the environmental factors as well as the
altitude. Within the physiological limit blood pressure varies between 120-160
systolic and 70-85 diastolic and has got minor variation during exercise and
stress (Natochin 2007).

In present study the distribution of mean blood pressure was observed
lower in the hill area (86.13 ± 10.45 mm Hg) than plain (99.08 ± 13.86 mm Hg).
Individuals above 40 year of age group had higher mean blood pressure
(95.34 ± 15.86 mm Hg) than the younger group below 20 year (83.81 ± 7.88
mm Hg) at Aizawl. Though, it was within the physiological limit. Amongst
the residents from Gangetic plain of Varanasi a similar trend was observed
Varanasi (Above 40 year 104.32 ± 13.79 mm Hg and below 20 year 91.99 ± 9.38
mm Hg). These values were statistically significant in the age group of 20 to
40 year \((p=0.001)\) and there could be small segment of individuals who may fall in the range of hypertension (Table No. 5.10). The male individual at both of the sites had higher mean blood pressure value (Aizawl 86.64 ± 9.78 mm Hg and Varanasi 99.14 ± 14.11 mm Hg) than the female individuals (Aizawl 85.29 ± 11.48 and Varanasi 98.91 ± 13.28) and this was uniformly found to be statistically significant \((p=0.001)\) (Table No. 5.11). Taking into consideration the type of occupation blue collar individuals had low blood pressure (Aizawl 91.78 ± 8.87 mm Hg and Varanasi 95.18 ± 12.69 mm Hg) than the white collar individuals (Aizawl 85.01 ± 10.40 mm Hg and Varanasi 100.95 ± 14.05 mm Hg) at both of the sites (Table No. 5.12).

A study from Africa and other Caribbean native individuals have shown positive correlation between body mass index and blood pressure in both sexes (Kaufman et al 1997), whereas a study from London in 1998 demonstrated that white collar men and women had low systolic and diastolic blood pressure with low body mass index amongst men (Ferrie et al 1998). In an Indian study from North-East Assam blue collar labourers were found to have high systolic and diastolic blood pressure amongst the female (126.22 and 66.74 mm Hg) than the male (115.20 and 62.67 mm Hg) (Wilson 1954) and similar finding were observed by Singh et al (1997) and Hazarika et al (2000) from North East.

In our study at both of the sites blue collar individuals had relatively low blood pressure than white collar because hard work keeps them a better opportunity to sustain low body mass index as well as promote excretion of extra salt in the urine. Amongst the residents of the Varanasi females had tendency of higher mean blood pressure (Table No. 5.10) than the Aizawl with high body mass index, though statistically it was nonsignificant (Table No. 5.6).
The dietary pattern did not affect the pattern of mean blood pressure at both of the site, though among the residents of Varanasi non-vegetarian consumers had higher blood pressure (100.57 ± 13.84 mm Hg) than vegetarians (96.93 ± 13.69 mm Hg) (Table No. 5.13). In the beginning of 20th century Saile (1930) observed that vegetarian have low blood pressure than meat eater in the same age group and this has direct correlation with the pattern of urinary sodium excretion. This observation has been supported by Israeli workers where vegetarian diet is associated with low blood pressure and high urinary potassium excretion than non-vegetarian (Ophir et al 1983).

Contrary to this Chinese studies have found high diastolic blood pressure in female vegetarians (Ko and Chang 1983). Most of the study from all over the world except few have supported that vegetarians have low blood pressure due to low dietary sodium intake and these observation have continued to be significant till the study from Lin et al (2010), where they found that diastolic blood pressure in the vegetarians was significantly higher. Since our study was basically concerned with cross sectional observation, we could only correlate positively between mean blood pressure and age group (Figure No. 5.18) as well as body mass index (Figure No. 5.19) at par with the studies reported from other countries as well as from North-East states from India. However the significant difference was observed in the residents of the Gangetic plain area of the Varanasi, where we found significant positive correlation between body mass index and mean blood pressure (Aizawl p=<0.001 & r=1.00 and Varanasi p=<0.001 & r=0.942) (Table No. 5.15).

There seems to be strong association of calorie intake between vegetarian and nonvegetarian diet at both of the sites in which the overall consumption of calorie was higher amongst non-vegetarian consumers (more than 2800 calorie) in the residents of Varanasi, whereas relatively lower calorie was being consumed by the Aizawl residents (Table No. 5.16). The
dietary calorie intake was higher in the younger age group and significantly ($p=<0.001$) low in the age group of 20 - 40 year and above 40 year at both of the sites (Table No. 5.17). We also observed that females consumed low calorie (2576.10 ± 335.24) than the male (2730.87 ± 276.10) in the Gangetic plain of Varanasi, whereas in Aizawl the consumption of overall calorie was significantly ($p=<0.001$) higher amongst the female residents (Table No. 5.18).

There was reversal of the pattern in the hill area of the Aizawl were female consumed more calorie than the male individual and this was well comparable with the nature of job in which white collar individuals in Aizawl consumed more calorie than their blue collar counter part, while in Varanasi blue color labour workers consumed higher calorie than white collar residents (Table No. 5.19). When individual component of the diet was considered amongst the non-vegetarian, protein content of the individuals from the Aizawl was significantly ($p=<0.001$) lower than the Varanasi individual, whereas no correlation could be established between carbohydrate content of vegetarian and non-vegetarian diet amongst Gangetic plain and hill area (Table No. 5.20). When gender was considered, female individuals from Aizawl consumed significantly ($p=<0.001$) higher amount of carbohydrate and protein than the Varanasi individual, whereas male individual in Aizawl consumed less carbohydrate and protein in comparison with Varanasi individuals (Table No. 5.21).

While calculating the main electrolyte component of diet overall there was no difference in sodium content of the diet between vegetarian and non-vegetarian individuals in Aizawl, whereas in Varanasi there was significantly ($p=<0.001$) higher dietary sodium content in non-vegetarian consumer than vegetarian (Table No. 5.22). When dietary potassium value was calculated, further there was higher potassium content amongst Varanasi residents then Aizawl. However amongst vegetarian eater potassium was on higher side in
the Aizawl hill area tribal in comparison to the non-vegetarian diet (Table No. 5.23). There was no difference when dietary sodium potassium ratio was considered at both of the site. The value was higher in the non-vegetarian consumers amongst Varanasi residents than residents from Aizawl (Table No. 5.24). The dietary calcium was significantly ($p=<0.001$) higher in the residents of Varanasi and much lower in the Aizawl individuals and similar pattern was observed in the chloride content of the diet in which higher value of dietary chloride was found amongst the residents of Varanasi which was significantly ($p=<0.001$) double of the value what was observed amongst the residents of Aizawl (Table No. 5.25 and 5.26). The extra dietary consumption of salt was significantly ($p=<0.001$) higher in both of the non-vegetarian group (Aizawl 6.48 ± 3.20 and Varanasi 9.20 ± 4.78) than the vegetarian (Aizawl 5.66 ± 2.37 and Varanasi 8.67 ± 4.55).

There is a scarcity of the literature regarding the overall calorie consumption and various component of the food in relation to hill and plain area. However a study by Melby et al (1989) had shown statistically significant correlation between dietary intake of Carbohydrate, protein, sodium as well as potassium intake with blood pressure. In another study, low sodium intake and high potassium intake was found in vegetarian (Wyatt et al 1995). A Chinese study by Woo et al (1998) found that elder subjects consumed low calorie diet and electrolyte component in vegetarian diet for example calcium, potassium and sodium is much low in the vegetarian diet. Furthermore study from Melbourne by Li Duo et al (2000) demonstrated that vegetarians have higher potassium intake with low dietary sodium potassium ratio than the non-vegetarian. Appleby et al (2002) demonstrated positive association of calcium intake with blood pressure in women and study from Taiwan (Yen et al 2008), the total carbohydrate consumption and calcium intake was significantly higher in vegetarian diet than non-vegetarian. A similar study
from Taiwan by Lin et al (2010) also demonstrated that vegetarian could have high diastolic blood pressure.

The association of dietary potassium and low blood pressure has been observed since 1928 by Addison, which was further confirmed by Woo et al (1998). However in Georgia study in black and white population showed a negative correlation between blood pressure and dietary potassium (Grim et al 1980). Many other studies (Geleijnse 1990) from Netherland, Rotterdam have shown that higher potassium intake is associated with low blood pressure, which has been further confirmed by (Bazzano 2001 and Green et al 2002) from Honolulu. In a similar study from India Krishna et al (1989) found low dietary potassium may increase significant blood pressure.

Studies regarding calcium intake and blood pressure have found inverse association by Smith (1977) and Witteman (1989) as well as Iso et al (1991), whereas a study by (Jorde et al 1999) showed increased blood pressure with higher dietary calcium intake. All over the world many studies have shown a positive correlation between high dietary sodium intake and blood pressure (Kihara et al 1984), Vollmer et al (2001), Nowson and Morgan (1988) and Francesco et al (2006). All the above studies can very well be compared with our present work with the only difference that our residents from Gangetic plain consumed higher calorie as well as higher protein diet than the hill area counter part. Further more in Gangetic plain of Varanasi the salt concentration was also significantly higher irrespective of non-vegetarian and vegetarian diet with high calcium and chloride content. This pattern could be a reflection of labors and blue collar workers, who have more opportunity to work in open field as well as the white collar individuals, who may have to commute long distance of travel in hot humid atmosphere. The relative high dietary content of the salt may be an adaptive response by compensating loss of electrolytes in urine and sweat and to prevent them from getting
dehydration and heat stroke. This observation would be further supplemented when other environmental factors as well as the other urinary excretory pattern of the electrolyte will be taken in to account.

The overall consumption of calorie was higher amongst the residents of Varanasi (2689.09 ± 300.37) than the residents of Aizawl (2316.38 ± 664.30) and there was positive linear correlation between carbohydrate intake and total calorie consumption at both of the sites (Aizawl $p=0.018$ & $r=0.721$ and Varanasi $p=0.016$ & $r=0.659$) (Figure No. 5.32). The consumption of protein was also higher in Varanasi (147.55 ± 42.65 gm) than Aizawl (127.80 ± 70.04 gm) and had positive correlation with calorie intake (Aizawl $p=0.012$ & $r=0.745$ and Varanasi $p=0.012$ & $r=0.632$) (Figure No. 5.33). However the carbohydrate intake of Varanasi residents was higher (587.98 ± 150.15 gm) than Aizawl residents (547.91 ± 272.09 gm) and had statistically highly significant positive correlation with protein intake at Varanasi ($p=<0.001$ & $r=0.251$) (Figure No. 5.34). When the different individual dietary component in relation to electrolyte was calculated, the overall consumption of sodium and potassium was much higher in Varanasi residents ($Na^+ 326.47 ± 118.02$ gm and $K^+ 3475 ± 1141.74$ gm) and when sodium and potassium intake was correlated, we found a significant positive correlation at Aizawl ($p=0.026$ & $r=0.965$) (Figure No. 5.35). Accordingly $Na^+$ and $Cl^-$ were also being consumed in higher quantity by the residents of Varanasi ($Na^+ 326.47 ± 118.02$ gm and $Cl^- 209.14 ± 100.43$ gm) than Aizawl ($Na^+ 183.50 ± 106.03$ gm and $Cl^- 120.20 ± 72.67$ gm) and there was significant positive correlation between $Na^+$ and $Cl^-$ intake (Aizawl $p=0.019$ & $r=0.866$ and Varanasi $p=0.041$ & $r=0.563$) (Figure No. 5.36). This dietary pattern also reflected in body mass index and calorie intake, where we found significant positive correlation at Aizawl ($p=0.043$ & $r=0.143$) (Figure No. 5.37). When the body mass index was compared with total carbohydrate intake, we found nonsignificant positive
correlation amongst the residents of Aizawl and negative correlation in the residents of Varanasi (Table No. 5.34). Similar pattern was also found, when protein intake was taken into account, where the residents of the Aizawl showed nonsignificant positive correlation with body mass index and protein intake and negative correlation in Varanasi individuals (Table No. 5.35). There was also positive correlation between dietary sodium intake and body mass index amongst Aizawl residents, while at the Gangetic plain of Varanasi negative correlation was observed (Table No. 5.36). The dietary chloride consumption of residents from Varanasi was higher (209.14 ± 100.43 gm) than Aizawl residents (120.20 ± 72.67 gm) and have statistically significant positive correlation with body mass index at Varanasi \((p=0.05 & \ r= -0.133)\) (Figure No. 5.43) and similar pattern continued in dietary K\(^+\) and Ca\(^{++}\) intake in which there have been positive correlation between Aizawl residents and negative correlation between Varanasi residents. Both of these correlations were statistically nonsignificant (Table No. 5.37 and 5.38). The higher body mass index amongst Varanasi residents is a direct reflection of relatively high intake of total calorie, protein, carbohydrate and higher salt which are added in abundance in almost all the spicy dishes as well as the snacks which are consumed quite often round the day than the residents of North East hill. This observation was made by Chinese worker (Woo \textit{et al} (1998) as well as Japanese (Appleby \textit{et al} 1998). In a study by Yen \textit{et al} (2008) from Taiwan on preschool children and their parents found individuals consuming vegetarian diet have high carbohydrate intake, higher total calorie consumption as well as Ca\(^{++}\) than the non-vegetarians.

Since population living in Varanasi consume more vegetarian diet than the north hill area of Aizawl, it is quite obvious that people of Aizawl will have low calorie consumption, low carbohydrate diet, lower electrolyte component of the food (Na\(^+\), K\(^+\), Ca\(^{++}\) and Cl\(^-\)) than the people in the plain.
This also reflects the casual consumption of snacks in form of more carbohydrate and fat like chips, samosa, kurkure and other cheaper edible objects, which is readily available in plain than in hill area where the processing of the diet and fast food is not easy. Furthermore higher value of \( \text{Ca}^+ \) in diet amongst the residents of Varanasi could be due to cultural tradition of consuming more dairy products in the form of sweets, lassi and milk resulting in high calcium than the Aizawl residents. Since no such study is available from Gangetic plain area it is difficult for us to compare though our results are at par with Chinese studies which have more cultural similarity with our North hill residents as both of them belongs to Mongolian race.

When the total calorie intake was compared with mean blood pressure at both of the sites no statistical significance could be established, though amongst the residents of Varanasi, mean blood pressure was higher (99.08 ± 13.86 mm Hg) than the Aizawl residents (86.13 ± 10.45 mm Hg) with nonsignificant negative correlation with dietary calorie and carbohydrate intake (Table No. 5.40 and 5.41). The protein consumption also did not show any statistically significant pattern at both of the site, but there was negative correlation between mean blood pressure and overall protein consumption (Table No. 5.42). The dietary \( \text{Na}^+ \) intake showed a negative correlation with mean blood pressure and statistically this was not significant (Table No. 5.43). When \( \text{K}^+ \) intake was taken in to consideration, this showed a statistically significant positive correlation with mean blood pressure amongst the residents of Varanasi (\( p=0.0293 \) & \( r=0.68 \)), whereas at the site of Aizawl, there was negative correlation and this was statistically nonsignificant (Table No. 5.44). The \( \text{Ca}^{++} \) intake did not showed any significant correlation with mean blood pressure at both of the sites (Table No. 5.45), whereas the \( \text{Cl}^- \) consumption was found to have negative correlation with mean blood pressure in Aizawl and positive in Varanasi without any statistical significance (Table No. 5.46).
The correlation between mean blood pressure and extra salt consumption showed a positive correlation, in which higher salt intake of 8.99 ± 4.68 gm was associated with high mean blood pressure (99.08 ± 13.86 mm Hg) at the site of Varanasi, but these data were nonsignificant at both of the sites (Table No. 5.47).

Dietary salt and potassium consumption has always remained a point of great interest to the nutritionist and clinician in prevention of BP programme ever since from the beginning of the 20th century. Though early studies in 1912 (Medico-Actuarial Mortality Investigation) as well as in 1932 (Adolph RF and Associates 1947) considered that there could be some correlation between high body mass index, high calorie, high protein as well as salt intake with blood pressure. Addison in 1928 found role of potassium salts in lowering the blood pressure and was subsequently confirmed by several studies by Grim et al (1980) and Ueshima et al (1981), however only in 1995 in a study by Wyatt et al found that low dietary sodium is associated with low mean blood pressure. In a Melbourne study by Li Duo et al (2000) the dietary Na⁺, K⁺ ratio has been considered as an important factor to have an important association with high blood pressure. Another similar study by Ascherio et al in 2001 found significant negative correlation between K⁺ intake and blood pressure and Green et al (2002) from Honolulu found inverse correlation of K⁺ with blood pressure in older individuals. The Indian study from Krishna et al (1989) found that, low potassium diet increases the risk of blood pressure. Considering the dietary Ca++ component Witteman et al (1989) reaffirmed the hypothesis that there is a linear correlation between dietary Ca++ intake and blood pressure. A study from Japan by Iso et al (1991) found inverse association and Osborne et al (1996) observed negative association between dietary Ca++ and blood pressure.
None of the above studies have taken into account the geographical distribution of the site neither they have considered all the parameter like calorie dietary protein, Ca\(^{++}\), Na\(^{+}\), K\(^{+}\) and Cl\(^{-}\) in a single group. Therefore our study can not be compared with these cross sectional observations. However two important observations have immerged from our study, that higher dietary salt consumption have a positive correlation with mean blood pressure within the physiological range, whereas higher dietary K\(^{+}\) plays an important role in prevention of the blood pressure. Both of these electrolytes (Na\(^{+}\) and K\(^{+}\)) depends upon type food in which high K\(^{+}\) diet is associated with vegetarian diet, whereas sodium could be associated with non-vegetarian, which contain additional sodium either in the form of preservatives or added salt during the cooking process. The dietary Ca\(^{++}\) depends on dairy products, whereas chloride is usually associated with salts and other various food items. The tradition of observing various religious rituals amongst the people of Varanasi could also be contributing factor for high dietary Ca\(^{++}\) and Cl\(^{-}\) intake and may be a co-factor in overall calorie consumption making individuals prone for high blood pressure. However physiological compensation by excreting these extra salts in the urine could also be a significant determining factor and will be considered in the subsequent discussion.

The urinary excretion of various electrolytes plays the main role in adaptation of the individuals in relation to variation in blood pressure and other anthropometric measures. Sodium being important component of the food has significant concentration in serum as well as in the urine and is excreted in the urine to balance the extra dietary load. In our observation amongst the residents of the Aizawl the value of urinary and serum Na\(^{+}\) was almost equal in the male individuals (Urinary Na\(^{+}\) 132.34 ± 55.75 meq/l and Serum Na\(^{+}\) 137.98 ± 12.60 meq/l), while in the female the excretion of mean
urinary Na\(^+\) was much lower (Urinary Na\(^+\) 129.01 ± 43.20 meq/l and Serum Na\(^+\) 137.82 ± 15.68 meq/l) than their female counterparts in Varanasi (Urinary Na\(^+\) 176.77 ± 68.43 meq/l and Serum Na\(^+\) 144.32 ± 13.39 meq/l) and this value was statistically significant \((p = 0.015 \& <0.001)\). There was no statistical difference in the mean urinary excretion of Na\(^+\) in either sex at both of the sites (Table No. 5.48). When the nature of job was taken into consideration the blue collar individuals at the site of Varanasi excreted more sodium in the urine (152.31 ± 65.98 meq/l), than their white collar counterparts (126.64 ± 68.89 meq/l). The lower value of serum sodium almost remains normal in both of the groups (Table No. 5.49). At the site of Aizawl individuals consuming vegetarian diet excreted more sodium in the urine (137.18 ± 39.60 meq/l), than the Varanasi residents (103.66 ± 47.91 meq/l) and this was statistically highly significant \((p=<0.001)\). On contrary amongst non-vegetarians the mean urinary excretion of Na\(^+\) was higher amongst the residents of Varanasi (156.75 ± 72.86 meq/l), than their Aizawl counterparts (129.64 ± 53.63 meq/l). Both of the values were statistically highly significant \((p=<0.001)\), whereas no difference was observed in serum sodium value amongst vegetarian and non-vegetarian consumers (Table No. 5.50). When value of serum and urinary K\(^+\) was considered, we observed overall higher excretion amongst female individuals at the site of Varanasi (Varanasi Serum 4.15 ± 0.71 meq/l and Urinary 84.72 ± 20.80 meq/l) (Aizawl Serum 3.84 ± 1.03 meq/l and Urinary 32.96 ± 15.86 meq/l), whereas male individuals in Aizawl had higher urinary excretion of potassium (Aizawl Serum 3.81 ± 0.84 meq/l and Urinary 31.74 ± 16.83 meq/l) (Varanasi Serum 4.20 ± 1.11 meq/l and Urinary 27.08 ± 14.50 meq/l). The values of serum and urinary excretion of K\(^+\) was normal amongst both male and female individuals of Aizawl, though none of the data were statistically significant (Table No. 5.51). There was no significant difference in the serum and urinary K\(^+\) excretion between blue and white collar individuals. However the overall values of both serum and
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Urinary $K^+$ were on the higher side amongst the Varanasi residents (Table No. 5.52). Vegetarian food consumers had a tendency to excrete more $K^+$ in the individuals of Aizawl than their non-vegetarian counterparts. However individuals from Varanasi had a tendency to excrete more $K^+$ amongst non-vegetarian food consumers. There was no statistical significant difference at both sites in the value of serum potassium (Table No. 5.53). The pattern of serum and urinary $Ca^{++}$ excretion in male and female was almost identical and no statistical difference was noted (Table No. 5.54). Nature of occupation did not affect the urinary $Ca^{++}$ excretion profile at both of the sites. However the serum $Ca^{++}$ value was found to be higher amongst the Aizawl residents (Blue collar $8.62 \pm 1.22$ meq/l and White collar $8.44 \pm 1.40$ meq/l) than Varanasi (Blue collar $7.84 \pm 1.55$ meq/l and White collar $7.94 \pm 1.63$ meq/l). A similar pattern was observed when serum and urinary $Ca^{++}$ was taken into consideration between vegetarian and non-vegetarian food consumers (Table No. 5.56). When serum and urinary chloride values were calculated no statistical difference was found at both of the sites in relation to gender, nature of job and dietary pattern (Table No. 5.57, 5.58 & 5.59).

Very few studies are available to compare our data in relation to serum and urinary excretion of electrolytes. However the Israeli vegetarian association study showed a high urinary potassium excretion amongst vegetarian food consumers (Ophir et al 1983). In a previous study by Armstrong et al (1979) the dietary sodium was not much affected by vegetarian and non-vegetarian food. In 2007 in a study by Nowson and Morgan found a significant positive correlation between dietary and urinary $Na^+$, $K^+$ ratio. In a West African study by Cappuccio (2006) the urinary $Na^+$ had a significant positive correlation with systolic blood pressure only.
In our observation only female individuals of Varanasi had a significant \( p=<0.001 \) higher urinary sodium excretion (Varanasi 176.77 ± 68.43 meq/l and Aizawl 129.01 ± 43.20 meq/l), whereas male individuals from Aizawl were found to have higher urinary sodium excretion (Aizawl 132.34 ± 55.75 meq/l and Varanasi 119.53 ± 62.48 meq/l) (Table No. 5.48). A similar pattern was observed in non-vegetarian diet consumers from the site of Varanasi in relation to serum and urinary sodium profile (Table No. 5.50). In the Varanasi residents female have tendency to consume more pickles and spicy food than their male counterparts, which has reflected in their higher dietary sodium content (287.74 ± 110.12 gm) and higher urinary excretion value (176.77 ± 68.43 meq/l), whereas no such cultural tradition exist in Aizawl residents which reflect low serum sodium (Male 137.98 ± 12.60 meq/l and Female 137.82 ± 15.68 meq/l) as well as lower urinary sodium excretion (Male 132.34 ± 55.75 meq/l and Female 129.01 ± 43.20 meq/l). The vegetarian food consumers of Aizawl had significant \( p=<0.001 \) higher excretion of \( \text{Na}^+ \) in the urine (Vegetarian 137.18 ± 39.60 meq/l and Non-vegetarian 129.64 ± 53.63 meq/l) and this reverse difference is difficult to explain. It could be a phenomenon of adaptation in the male counterpart to protect them from developing hypertension who are exposed to less hard ship and manual work than the female residents.

Since urinary \( \text{Na}^+ \) excretion is an important parameter in deciding the mean blood pressure depending upon the dietary consumption of the \( \text{Na}^+ \) as well as change in atmospheric condition, we observed a statistically significant negative correlation \( p=0.0266 \ & r= -0.157 \) in the residents of Aizawl, whereas in the residents of the Varanasi this showed a nonsignificant linear positive correlation (Table No. 5.60). There was statistically significant positive correlation \( p=<0.001 \ & r=0.381 \) between serum \( \text{Na}^+ \) and mean blood pressure in the residents of Varanasi (Table No. 5.61). The urinary \( \text{K}^+ \)
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Excretion was almost identical at both sites. However there was no correlation between urinary K⁺ excretion and mean blood pressure in the hill areas of the Mizoram (Table No. 5.62). The serum K⁺ value was found to be statistically highly significant positive correlation \( (p<0.001 \& r=0.370) \), whereas this was statistically insignificant amongst Aizawl residents and has shown the tendency of negative correlation (Table No. 5.63). Urinary Ca²⁺ excretion though had a linear trend amongst both the residents of Aizawl and Varanasi but, it did not show significant correlation (Table No. 5.64 and 5.65). Similar pattern was observed between blood pressure and urinary Cl⁻ excretion at both of the sites, whereas there was a negative correlation between serum Cl⁻ and mean blood pressure amongst Aizawl residents (Table No. 5.66 and 5.67).

There are many physiological considerations to decide the pattern of urinary excretion of electrolytes amongst healthy individuals based on dietary consumption and environmental factors. In the residents of the Aizawl the dietary consumption of Na⁺ was significantly on the lower side amongst both vegetarian (183.39 ± 119.96 gm) and non-vegetarian (183.53 ± 102.90 gm) and this reflected in almost identical pattern of urinary Na⁺ excretion (Vegetarian 137.18 ± 39.60 meq/l and Non-vegetarian 129.64 ± 53.63 meq/l), which could have been the reason of mean blood pressure of Aizawl residents on lower side (86.13±10.45 mm Hg). It’s quite apparent with our observation that the Aizawl residents continue to excrete more Na⁺ (Urinary 131.07 ± 51.25 meq/l) in spite of low dietary intake (183.50 ± 106.03 gm) and thereby remain protected from the rise of blood pressure. It’s quite possible that the individuals living in the plain area compensate the urinary excretion by loosing more salt in urine as well as in sweat. Thus Aizawl residents are better adapted for their urinary excretion in spite of low dietary Na⁺ intake, which is manifested in the form of a negative correlation \( (p=0.0266 \& r=-0.157) \) (Figure No. 5.73). On contrary individuals from Varanasi have a positive correlation,
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excrete less Na\(^+\) (Urinary 134.98 ± 68.85 meq/l) than their dietary intake (326.47 ±118.02 gm) and therefore have higher mean high blood pressure (99.08 ± 13.86 mm Hg) than their Aizawl counterparts (86.03 ± 10.45 mm Hg) (Table No. 5.60).

High dietary K\(^+\) content have been found to be protective in blood pressure by many workers (Melby et al (1989), Li Duo et al (2000) and Ophir et al (1983) and this was observed, ever since studies by Addition (1928), Ascherio et al (1998) and Green et al (2002). There is only one such study by Krishna et al (1989), where as Kaplan and Rose (2009) demonstrated s positive correlation between dietary K\(^+\) intake and urinary Na\(^+\) excretion. Thus our finding can well be comparable with many international studies, though there are no comparative data of the individuals at different altitude and socio cultural backgrounds. As the mean blood pressure was always on lower side in Aizawl residents, we observed a negative linear correlation and similar trend was also seen in serum Ca\(^{++}\) and serum Cl\(^-\) value. Majority of the individuals at Aizawl were non-vegetarian and therefore had higher serum Ca\(^{++}\) than Cl\(^-\) value which physiologically would have reflected in higher urinary excretion than the individuals from Varanasi. This could be an adaptive phenomenon in regulation of hypertension and therefore protects many tribal communities from developing hypertension whose life style is close to nature. In Gangetic plain this natural protection privilege is lost and hence forth residents of Varanasi are at disadvantage of consuming more dietary salt inform of Sodium chloride as well as calcium and potassium and could be victim of developing high blood pressure.

Salt and electrolyte homeostasis has been a major concern towards adaptation in human being in maintaining blood pressure within the physiological limit and has been also important observation in the present study. In our observation Aizawl residents had low blood pressure during
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summer (84.52 ± 8.55 mm Hg) and winter (92.72 ± 14.43 mm Hg), whereas Varanasi residents had relatively higher blood pressure in summer (99.28 ± 13.98 mm Hg) than winter (94.75 ± 10.50 mm Hg). The ambient temperature and calorie intake have shown a linear correlation with no statistical significance (Table No. 5.69). There was nonsignificant negative correlation ($r= -0.106$) amongst the residents of Varanasi between ambient temperature and carbohydrate intake, whereas in the residents of Aizawl this had a statistically significant positive correlation ($p=0.0266$ & $r=0.157$) (Table No. 5.70). The protein intake was identical at both of the site in relation to temperature variation (Table No. 5.71). However the urinary Na$^+$ excretion was on higher side amongst Varanasi residents than the Aizawl and there was non significant positive correlation (Table No. 5.72). The serum Na$^+$ pattern in relation to ambient temperature have shown a statistically significant positive correlation ($p=0.003$ & $r=0.207$) amongst the Aizawl residents than Varanasi, whereas no significant correlation could be established between urinary K$^+$ excretion at both of the sites, though in Varanasi residents the overall urinary K$^+$ excretion was significantly high (Table No. 5.73 and 5.74). We observed statistically significant negative correlation ($p=0.041$ & $r=-0.144$) between serum K$^+$ and ambient temperature amongst Aizawl residents while in Varanasi there was non significant positive correlation (Table No. 5.75). There was no statistical difference in urinary Ca$^{++}$ and ambient temperature at both sites, whereas serum Ca$^{++}$ was found to have negative correlation at both of the sites with ambient temperature variation (Table No. 5.76 and 5.77). The value of urinary Cl$^-$ excretion showed a statistically significant positive correlation ($p=0.0186$ & $r=0.166$) pattern with ambient temperature amongst Varanasi residents but this was statistically nonsignificant in Aizawl residents (Table No. 5.78) However there was negative correlation between ambient temperature and serum Cl$^-$ value at the site of Varanasi and positive at Aizawl but both of them were nonsignificant (Table No. 5.79)
In the Western countries there are studies to support that there has been seasonal influences over blood pressure and body mass index. In a study by Rose (1961) from UK the seasonal influence has been described on blood pressure. The Heller \textit{et al} (1978) had found inverse correlation between diastolic blood pressure and room temperature. Brennan \textit{et al} in 1982 observed that urinary Na\textsuperscript{+} excretion has been higher during winter than the summer and a joint study from US, Great Britain and Australia among school children has found a significant correlation (Jenner \textit{et al} (1987) and De Swiet \textit{et al} (1984). A study by Kristal-Boneh \textit{et al} (1996) found inverse association between blood pressure and body mass index, where as Argilés \textit{et al} (1998) from Germany have shown highest mean blood pressure during winter and lowest during summer. In 2006 Modesti \textit{et al} established an inverse correlation between air temperature and systolic blood pressure. In a study from 3 French cities blood pressure was significantly low during spring and summer by Alpérovitch \textit{et al} (2009), while study from Bostan demonstrated inverse correlation between temperature and blood pressure Halonen \textit{et al} (2010).

Our observation has been consistent between the residents of the Aizawl and all other Western studies where mean blood pressure has been found high during winter though it was statistical non significant, where as in Varanasi residents a reverse pattern was observed. This difference could be because most of the Western studies are from US, UK and Europe and has been based upon higher altitude while none of the study are from the plain tropical sites where there is extremes of the temperature variation and significant difference in the life style of the dietary pattern of the individuals. However our study supports the observation that residents of Aizawl are better adapted for their ambient variation in temperature since they had narrow range of temperature variation \(22.73 \pm 2.45 \, ^{0}\text{C}\) than the Varanasi
(35.75 ± 6.40 °C). There is only one study by Kristal-Boneh et al (1996), where body mass index has been found to vary with seasonal variation. However in our case, we did not find any such change and this could be explain by further better adaptability by the Aizawl residents during winter season (BMI Aizawl 22.71 ± 3.55 and Varanasi 22.16 ± 3.45). There is further possibility that better natural physical exercise during winter season by the Aizawl residents keep them well compensated and equal to the residents of the plain against the conservation of the body heat which was not required during summer season. During hot summer there is increased sweating as well as loss of fluid and electrolyte from the urine and this is more pronounced amongst the residents of Varanasi, whose body mass index is on higher side more (23.97 ± 3.69) and have higher body surface area. In Varanasi most of the residents wear light clothing, drink more water and consume more salt to protect themselves from heat stroke.

In 1910 famous physiologist Harvey demonstrated that when an individual is exposed to high Altitude of 18000 feet above sea level they compensate by diuresis of an alkaline urine. In 1929 Norn also demonstrated that during morning time there is increased excretion of Na⁺, K⁺ and Cl⁻ in urine. Same observation was supported Devis et al (1920-21). In simulated experiment by Marrie et al (1944) from Chicago on a fixed diet of 2750 calorie containing 3.29 gm Na⁺, 3.27 K⁺ and 4.93 Cl⁻ found, that there has been temporary rise in excretion of all the three electrolytes, whereas Hennon et al (1970) from USA observed that both serum Na⁺ and K⁺ are decreased at high altitude whereas Ca²⁺ and Cl⁻ value remain high. The Japanese worker have also demonstrated of significant low serum Ca²⁺ and high serum K⁺ at high altitude. A similar study Galster Morrison (1973) observed high urinary Na⁺ and K⁺ excretion at high altitude. There has been only one study from Saudi Arabia in which individuals from plain have been studied and have shown,
that higher blood pressure and body mass index in high lenders than low lenders (Khalid et al 1994). A comparative study by Zaccaria et al (1998) on human acclimatization found that urinary Na\(^+\) excretion increases at high altitude, whereas study from turkey Arslan et al (2003) found positive correlation between body mass index and blood pressure at high altitude. There has been only one Indian study by Amitabh et al (2009) in which low body mass index has been found at high altitude with high systolic blood pressure and diastolic blood pressure, than the residents of the plain area. These observations could well be correlated with all the parameters amongst the residents of Aizawl where high urinary Na\(^+\) excretion has remained a major adaptive factor in regulation of the blood pressure during summer in which it was low (84.52 ± 8.55mm Hg), where as during winter it was found to be identical with the residents of Varanasi due to low excretion of Na\(^+\) in the urine. Other electrolytes like K\(^+\), Ca\(^{++}\) and Cl\(^-\) were statistically insignificant and did nor affect our targeted population at both of the site because these individuals are well adapted to seasonal variation.

The North-east area has been blessed by the nature with an unique climatic privilege of high humidity round the year than the residents of the Gangetic plain of the Varanasi and has been the major cause of change in food habits as well as the physiological adaptations. Accordingly there has been no significant variation in the calorie intake amongst the Aizawl residents where as at the site of Varanasi there was negative correlation between calorie intake and relative humidity and this was statistically significant (p=0.001 & r= -0.222) (Table No. 5.80). At both of the sites, we observed negative correlation between carbohydrate intake, protein intake with humidity, whereas amongst Varanasi residents, there was statistically highly significant (p=<0.001) positive correlation (r=0.253) between relative humidity and urinary Na\(^+\) excretion (Table No. 5.81, 5.82 and 5.83). Serum sodium was found to have
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statistically significant positive correlation with relative humidity at both sites of Aizawl ($p=<0.001 \& r=0.271$) and Varanasi ($p=0.004 \& r=0.202$) (Table No. 5.84). On contrary at both of the sites, there was a positive correlation between serum $K^+$ and relative humidity and this was found to be statistically highly significant (Varanasi $p=<0.001 \& (r=0.231)$ amongst the residents of Varanasi (Table No. 5.86). The urinary $K^+$ excretion showed a negative correlation at the site of Varanasi and positive at Aizawl, though both were statistically not significant (Table No. 5.85). No difference was observed in urinary $Ca^{++}$ excretion at both of site, when relative humidity was taken in to account, however there was statistically insignificant negative correlation at the site of Varanasi (Table No. 5.87). We observed negative linear correlation between serum $Ca^{++}$ and relative humidity at both of the sites (Table No. 5.88). There has been consistent negative linear correlation in serum and urinary $Cl^-$ excretion amongst the residents of Varanasi though statistically none of them were significant (Table No. 5.89 and 5.90).

Humidity has not been considered by many workers as an important variable in relation to various factors of adaptation by the environmental scientist. However with the human physiological point of view this plays an important role in deciding the excretion of various electrolytes in the urine and sweat. Tropical zone where humidity has been consistently high round the year creates an environment where there is increased loss of solvent through sweat, which reflects in decreased urinary electrolytes excretion. This also affects the total body water and their by could predispose to the individuals towards high blood pressure. None of the study from western countries have considered this point however most of the study from North-East hill area from Meghalay and Mizorum has found significant positive correlation between age and systolic blood pressure. These workers have not differentiated the serum and urinary pattern, however the consistent high
humidity in this area could have reflected in moderate Na\(^+\) excretion as a result of low serum Na\(^+\) value (137.92 ± 13.82meq/l), low dietary intake of Na\(^+\) (183.50 ± 106.03gm) and have resulted in better adaptation of mean blood pressure in high humid environment than the residents of Varanasi. In western countries the humidity tends to be higher during winter season and in a study from UK by Medical Research Council Middlesex have shown higher systolic blood pressure and diastolic blood pressure and have also shown higher urinary Na\(^+\) excretion which was greater in older subjects than the younger one (Brennan et al 1982). Further the German study by Argilés et al (1998) has further supported highest mean systolic blood pressure and diastolic blood pressure during winter, where humidity is higher than the dry summer. Our observation has been consistent with the above parameter and the Aizawl residents showed almost identical urinary Na\(^+\) excretion value (131.07 ± 51.25meq/l) with Varanasi residents (134.98 ± 68.85meq/l), which was statistically highly significant (\(p=<0.001\)) and the serum Na\(^+\) was statistically highly significant (\(p=<0.001\)) amongst Aizawl residents with a positive correlation (\(r=0.271\)). These two parameters are robust evidence to support our finding that Aizawl residents are able to maintain normal blood pressure in spite of high humidity, high altitude as well as higher urinary Na\(^+\) excretion in relation to dietary sodium intake.

It appears that none of the other electrolytes i.e. Ca\(^{++}\) and K\(^+\) play significant role in relation to altitude and humidity and the major adaptive changes with environmental variation depends upon salt content of the food, capacity to handle sodium excretion by the kidney and body mass index, which is decided by genetic as well as socio-cultural variation of occupation and the food habits. These observations are more pertinent while planning industrialization of the urban area and also to prevent the migration of skilled and unskilled individuals from rural to urban side especially amongst the
hilly tribal residents whose migration to the plain area may affect their lifestyle and health and also could affect their work capacity. All these parameters are also of the importance in formulation of the national health policy of the residents of Aizawl who may have propenicity to migrate in the plain area for better job opportunity and could also be at risk to their health and therefore they need protection as well as extra health care considering their environmental factor at the native place.