CHAPTER 2

Seasonal Variation of Average Ozone as Related to Natural Vitamin-D Molecule

The duration of vitamin D production depends not only on the latitude and time but also on other parameters, most importantly total ozone. A dramatic effect of seasonal and latitudinal changes of solar UV radiation on vitamin D synthesis was revealed by (Webb et al., 1988). The role of ozone in the atmosphere acts as a filter. The ultraviolet radiations range between 290-315nm is very useful to the human being for synthesis of Vitamin D3. Ozone unique physical properties allow the ozone layer to act as our planet's sunscreen, providing an invisible filter to protect all the life from the Sun's damaging ultraviolet (UV) rays. Without the protective effect of ozone, life on the Earth would not have evolved the way it has. The ozone layer protects us from the harmful effects of certain wavelengths of ultraviolet (UV) radiation from the Sun.

UV-B radiations from the Sun can benefit health, generating vitamin D production in the skin. The required amount of radiation is, however, quite small: in summer, an exposure of 15 minutes to the hands and face is adequate. Vitamin D is also found in food. A normal diet will provide enough vitamin D for the people even in the winter.

Because skin is an important immunological organ, the immune system is vulnerable to modification by environmental agents, including UV-B radiations. Demonstrations show that immunity can be perturbed by exposing skin to UV radiations and ozone depletion might adversely influence immunity to infectious diseases. The danger to our immune system comes from ultraviolet radiations, mainly from the UV-B range of the spectrum, although UV-A pose some risk, if exposure is long enough. Any significant decrease of ozone in the stratosphere would result in an increase of UV-B radiation reaching the Earth's surface, and a weakening of immunity against the disease. The atmosphere of the Earth may be divided into several distinct layers. The troposphere is where all the weather takes place; it is the region of rising and falling packets of air. The air pressure at the top of the troposphere is only 10% of that at the sea level (0.1 atmospheres). There is a thin buffer zone between the troposphere and the next layer called the tropopause.
Above the troposphere is the stratosphere where air flow is mostly horizontal. The thin ozone layer in the upper stratosphere has a high concentration of ozone, a particularly reactive form of oxygen. This layer is primarily responsible for absorbing the ultraviolet radiation from the Sun. The formation of this layer is a delicate matter, since only when oxygen is produced in the atmosphere an ozone layer form and prevents an intense flux of ultraviolet radiation from reaching the surface, where it is quite hazardous to the evolution of the life. There is considerable recent concern that the man made fluorocarbon compounds may be depleting the ozone layer, with dire future consequences for the life on the Earth. While we often have too much ozone around us, the concentration of ozone is high in the stratosphere.

Above the stratosphere is the mesosphere and above that is the ionosphere (or thermosphere), where many atoms are ionized (have gained or lost electrons so that they have a net electrical charge). The ionosphere is very thin, but it is where aurora takes place and it is also responsible for absorbing the most energetic photons from the Sun, and for reflecting radio waves, thereby making long-distance radio communication possible. The structure of the ionosphere is strongly influenced by the charged particle of wind from the Sun (solar wind), which is in turn governed by the level of solar activity. One measure of
the structure of the ionosphere is the free electron density, which is an indicator of the degree of ionization.

2.1. Ozone Produced in the Atmosphere

Ozone is produced mainly in the upper stratosphere through the photo dissociation of oxygen by ultraviolet radiation from the sun. The photo lying radiation must have a wavelength shorter than 242nm to have sufficient energy to break the oxygen bond. Ozone itself also strongly absorbs ultraviolet radiation and can itself be photo dissociated. Hence a photochemical equilibrium is established between the production and loss mechanism that depends on the particular region of the atmosphere being irradiated.

The chemical equations describing this process, (Chapman S., 1930) are given below:

\[ \text{Formation} \]
\[
\begin{align*}
O_2 + h\nu (\lambda < 242nm) & \rightarrow O + O \\
O_2 + O + M & \rightarrow O_3 + M
\end{align*}
\]

\[ \text{Destruction} \]
\[
\begin{align*}
O_3 + h\nu & \rightarrow O + O_2 \\
O_3 + O & \rightarrow 2 O_2
\end{align*}
\]

The overall reaction between oxygen and ozone formation is:

\[ 3 \text{O}_2 \leftrightarrow 2 \text{O}_3 \]
From reaction (1) and (2) it can be seen that reaction (1) is limited by the amount of UV radiation available since there is an abundant supply of oxygen and reaction (2) favours reactions at higher pressure, lower altitudes, since there are more molecules for three body collision. The M in the reaction (2) symbolize third molecule. Hence the production of the ozone will be vary with the radiation path throughout the atmosphere and hence the sun angle. Therefore, more ozone produced over tropical region than over polar region and also at altitudes where sufficient radiations of wavelengths <242nm and sufficient atmospheric density for body collisions is available.

Besides photo dissociation, the other significant sink for ozone is their reaction with any ox disable material in the atmosphere since it is such a strong oxidizing agent. Because of the turbulent mixing in the troposphere, any ozone penetrating into the troposphere has a relatively short life time and hence the concentration of ozone in the troposphere is much lower than in the stratosphere (Matthews WA, 1991)

2.2. Ozone Depletion Effect

Under the prevailing natural equilibrium condition, there are only small dosages of UV radiation reaching the surface to which population; living organism, plants and aquatic systems have generally become adapted (Caldwell et al., 1989). The harmful effects are thus considered
to be generally very small. This, however, may not be true for the least studied geographical regions of the tropics and the equatorial belt in the context of ultraviolet radiation climatology and related adverse effect (Ilyas, 1988, 1989b, 1990).

The most direct effect of ozone layer depletion is the damage to human skin due to an increase in the surface level solar ultraviolet radiation. In general, the radiation reaching the surface may cause damage to human (skin, eyes, immune system, etc.) (Urbach, 1969; Diffey, 1982), vegetation (Terramura AH, 1987), marine ecosystem (Worrest RC, 1986) and materials through direct radiation energy effect. The UV radiation may also enhance the production of reaction chemicals including ozone at the surface level. Being very reactive and toxic, ozone at surface is harmful to humans, plants and vegetation, animals and damaging to certain material including rubber and paints. Near the surface, ozone also acts as a greenhouse and may contribute to the earth’s greenhouse warming and climate change.

Ozone layer depletion would cause more UV radiation to filter through the absorbing layer and reach the earth’s surface and enhance the potential adverse effects. It is estimated that at mid latitude, certain kinds of skin cancer would increase by 4% to 8% for 1% ozone layer depletion. The surface dosage of natural UV radiation substantially
increases from high and mid-latitudes to the equator (Ilyas, 1988, 1989b; 1990). Generally it is seen that people living in the high UV dosage tropical belt (where most developing countries are) have a darker skin tan, which is believed to provide greater protection in the skin against ultraviolet radiation penetration and damage. As a result, this high UV radiation situation has not been given much serious attention in the context of adverse health and environment effect that might be occurring in these regions under the prevailing environmental conditions. However, the human tan in a substantial part of the tropics is to the lighter side e.g. South-East Asia, North India (especially Kashmir), Pakistan, Afghanistan, Iran, Middle East, Egypt and Northern Africa. It is also important to assess the potential effect of any ozone layer depletion on the surface level UV flux at the equatorial tropical latitudes and how this increase may enhance the adverse bio-medical and other effect.

2.3. ChloroFloro Carbons and Ozone Depletion

Ultraviolet radiation of different wavelengths varies both in the amount of energy available per quantum and its effect in the atmosphere. While these differences are mostly progressive with wavelengths, they can usefully be grouped into three general wavelengths range, labelled in the order UV-A, UV-B and UV-C as
wavelengths decrease and energies increase. UV-A radiation behaves much like the visible violet radiation, passing essentially unimpeded throughout the whole atmosphere because the atmospheric components are almost transparent to it. In sharp contrast, all UV-C is completely intercepted by the atmospheric molecules at high altitude. Some of UV-C absorbed by the abundant component O$_2$ which amount for 21% of the Earth’s atmosphere (second only to the 78% of the molecule nitrogen N$_2$). Absorbed UV-C, divides the O$_2$ molecule to create the tri atomic form of oxygen known as ozone, O$_3$. This process show in the reactions (1), (2), (3) and (4).

Ozone itself is a very strong absorber for UV-C while splits it into O plus O$_2$, as in (3). With both O$_2$ and O$_3$ competing for its absorption, UV-C radiations readily removed in the upper atmosphere and do not penetrate below an altitude of about 25 kilometres.

Much of the intermediate energy UV-B radiation is absorbed in the atmosphere, but a fraction penetrates all the way to the Earth’s surface. The only significant atmospheric absorber of UV-B is ozone. Because the atmospheric components other then ozone are transparent to UV-B radiation, the penetration of UV-B toward the surface is strongly dependent on how much ozone is present, the greater the total ozone concentration, the less UV-B reaches the Earth’s surface, and vice-versa.
Many of the concerns about depletion of the atmospheric ozone layer are derived from this knowledge that lessened concentration of \( O_2 \) will permit increased penetration to Earth’s surface by UV-B radiation (Rowland FS., 1975).

In summary, the incessant solar bombardment of our atmosphere with UV-C radiation has created molecules of ozone, which then play a crucial role in intercepting additional solar ultraviolet radiation, both UV-C and UV-B. Some UV-B does reach the surface of the Earth, but much UV-B and all UV-C radiation is absorbed by ozone layer, or ozone shield. The CFC molecule absorbs ultraviolet energy only in the UV-C range. Because the CFCs are transparent to visible, UV-A and UV-B radiation, they are completely protected near the Earth’s surface by this stratosphere ozone shield. Only after the CFCs drift up into the atmosphere above most of the ozone and most of the \( O_2 \) are exposed to intense, unshielded solar UV-C radiation which can cause their decomposition.

In 1974, Dr. Molina and Rowland performed calculation of the altitude at which the CFCs would be decomposed, and how long it would be required on an average for the molecules to reach an altitude where destruction could occur. Our conclusion was that the average molecule of CFC-11 or CFC-12 would drift up above the ozone layer
and be decomposed by solar UV-C radiation only after a very long time
and be many decades to more than a century. We initially estimated the
average atmosphere life time for CFC-11 as 40 to 80 years, and that for
CFC-12 as 75 to 150 years. However, when the inert CFC molecule do
de-compose at these high altitude, they do so with the loss of atomic
chlorine, as in (4) and (5) for CFC-11 and CFC-12 (Molina LT and
Rowland FS, 1974; Rowland FS and Molina LT, 1975).

\[ \text{CCl}_3\text{F} + \text{UV-C} \rightarrow \text{Cl} + \text{CCl}_3\text{F} \]  \hspace{1cm} (5)

\[ \text{CCl}_2\text{F}_2 + \text{UV-C} \rightarrow \text{Cl} + \text{CClF}_2 \]  \hspace{1cm} (6)

The release of these chlorine atoms is the conceptual step, which
transformed our interesting scientific puzzle into a major global
environment problem. Unlike the which are so inert that some survive
unharmed in the atmosphere for the entire century, the atomic chlorine
from (5) or (6) is exceptionally reactive and finds a stratospheric
chemical partner within one or two seconds. By far the most common
high altitude reaction of atomic chlorine is known in (7) direct attack
upon ozone, the protective shield for both the CFC molecules and the
living inhabitants on the surface of the earth. The products of this
reaction are chlorine oxide, ClO, and ordinary oxygen, O\(_2\). The chlorine
oxide can then intercept an oxygen atom, re-releasing the chlorine atom,
as in (8). The net result of these two reactions is that ozone is neither removed from the atmosphere nor converted permanently into some other chemical form.

\[ \text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \quad (7) \]

\[ \text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2 \quad (8) \]

Net:

\[ \text{O} + \text{O}_3 \rightarrow \text{O}_2 + \text{O}_2 \quad (9) \]

Because the usual reaction of O atoms involves the formation of O\(_3\) by (2), the effect of (9) is really the equivalent to removal of two ozone molecules. Reaction comparable to (9) occur in the natural stratosphere, including a small amount of (7) plus (8) but this combination, when initial from man-made compounds, represents a new additional pathway for ozone removal. The newly free atomic chlorine again seeks out another ozone molecule and repeats the series, forming another chlorine oxide which will then react with an oxygen atom, once again releasing atomic chlorine, etc (Stolarsk RS et al., 1974). The sequence can be repeated many thousands of times, and the overall process is called a catalytic chain reaction, when atomic chlorine is the catalyst chain is describe as the ClO\(_x\) chain (i.e., x=0 or 1). Natural catalytic chain also exist involving NO\(_x\) (NO, NO\(_2\) and HO\(_x\) (H, HO, HO\(_2\)). The ClO\(_x\) chain can be temporarily diverted through
alternate reactions such as (10) and (11) which put Cl into other chemical molecules such as HCl or Chlorine nitrate (ClONO\(_2\)).

\[
\text{Cl} + \text{CH}_4 \rightarrow \text{HCl} + \text{CH}_3 \\
(10)
\]

\[
\text{ClO} + \text{NO}_2 + \text{M} \rightarrow \text{ClONO}_2 + \text{M} \\
(11)
\]

While in these reservoir compounds the Cl atoms are not removing ozone. However, these reservoir molecules are themselves temporary in the atmosphere and the chlorine is soon set loose again. The chain process continues in repaid bursts of ozone removal interrupted by quiescent reservoir periods as long as the chlorine remains in the stratosphere by and the average number of ozone molecules destroyed per individual chlorine atom is eventually about 100,000. The yearly release to the atmosphere of more than one million tons of CFCs, coupled with chain lengths of 100,000 per chlorine atom, makes it possible for man’s effects on the atmosphere to rival natural process on a global scale. Dr. Molina and Rowland predicted in 1974 that continued steady of the CFC molecule to the atmosphere would eventually lead to a of 7% to 13% of global ozone (Molina LT and Rowland FS, 1974; Rowland FS and Molina LT, 1975), and called for a halt to further emission of CFCs to the atmosphere.
The calculation in 1974 also indicated that actual atmospheric measurement would show that relative concentration of CFC-11 decrease rapidly above an altitude of 15 kilometres, with little left above 30 km. Most of the ozone lies in a band at altitude between 15 to 30 km. We also stated that there would be very little change in the relative concentration of CFC-11 or the other CFCs at altitude below the stratosphere.

2.4. Measurement of Average Ozone

We can measure total ozone in the atmosphere by satellite instrument like that Nimbus-7, TOMS, etc. Ozone is important factor for the synthesis of Vitamin D in skin because ultraviolet radiation depends on the ozone condition in the atmosphere. Consequently UV-B radiation intensity decrease after passed through ozone. So our conclusion in this study is that the thicknesses of ozone provide the useful UV-B radiation which is beneficial and helpful in the synthesis of vitamin D in skin. The study of ozone thickness in Dobson Unit can measure at particular latitude, longitude, altitude and used other parameter by TOMS. The seasonal variation of ozone thickness with the time of year and time of day at the particular longitude and altitude, may measure. Total ozone has been measured using Dobson instrument; however, truly global monitoring has been possible only since the introduction of satellite-
based instrument. In our country we have used the total ozone measured by Dobson Spectrometers and NIMBUS-7, total ozone mapping spectrometers (TOMS) operated from 1st November 1978 to 5th May 1993 and Meteor-3 TOMS operated from 22nd August 1991 to 27th Dec.1994. The data of total ozone concentration measurement by TOMS instrument with related to the study of Vitamin-D3. The measurement duration of average total ozone from 1st January 2005 to 31st October 2008 at Delhi by TOMS instrument has shown in fig.2.0. Seasonal variation of ozone has found that the 48DU average ozone decrease from 1st January to 31st October 2005 and total average change in 2006 and 2007 are 18DU and 17DU respectively. From 1st January to 31st August 2008 is small change, increase of 5DU in concentration of total ozone.
Figure 2.0. Average amount ozone from 2005 to 2008
2.5. Average Ozone as Related to Vitamin-D

The vitamin D solutions at the centre of the experiments give the best indication of whether any previtamin D was formed at that time and those conditions, and note whatever the UV measurements or the FastRT model predict. The FastRT UV simulation tool is by no means perfect. The program is designed to have uncertainties better than current high quality UV measurements when all input parameters are known (Engelsen O and Kylling A, 2005). Those measured irradiances are somewhat lower than those we would normally obtain for corresponding cloudless sky simulations at that time and location, using the FastRT simulation tool.

UV-B photons are partially absorbed by atmospheric ozone and the amount of UV-B reaching the ground is very much dependent upon the total atmospheric ozone. The role of UV-B photons for natural process of synthesis of vitamin D₃ is most important for human health (S.D. Sharma et al., 1997). High levels of UV-B photons have been observed directly in association with the Antarctic ozone hole. The evidences are overwhelming that under cloud free skies UV-B is controlled largely by ozone. Ozone depletion specifically enhances the shorter wavelengths of the UV-B i.e. 290-315nm, to reach the Earth's surface (R.A Rodhaine et al., 1997). The time required to obtain the
recommended UV dose for adequate vitamin D₃ synthesis in human skin depends on the solar elevation angle, as well as the surface and atmospheric conditions (Edwardsen et al., 2007).

A biological effective UV dose (BED) for photo conversion of 7-dehydrocholesterol to previtamin D in skin (M Brustad, EAlsaker et al., 2004). No detectable photo conversion of 7-DHC to Previtamin D₃ for mid-February and only a small production of previtamin D₃ at mid-March in Boston. The photo conversion of 7-DHC to provitamin D₃ in skin depends on latitude, longitude and altitude act. In clear atmospheric condition, a vitamin D occurs at 51° latitudes and higher. At 70° latitude, dermal vitamin D synthesis can be absent from 5October through 10 March in Boston.

We have described a method to estimate the duration of vitamin D synthesis in terms of time and location as well as surface and atmospheric condition. The quantity and availability of information on the relevant surface and atmospheric parameter such as total ozone, clouds aerosol and snow cover have now greatly improved from recent advanced science, meteorological model and satellite data. The vitamin D winter seems not as extensive as in (Webb A R, L Kline et al., 1988). Conversely, clouds, aerosol and thick ozone events reduce the duration of vitamin D synthesis consideration, and can force a "vitamin D winter "even at the equator."
In clear atmospheric conditions, a vitamin D winter occurs at 51° latitude and higher fig. 2.1, table 2.1. The main parameters influencing UV radiation (ozone, aerosols, clouds, albedo and altitude) roughly speaking shifts the extent of the dark field, i.e. the vitamin D winter, in fig 2.1 up or down while the essential shape is preserved.

In the event the measured irradiances were incorrect and our cloudless sky simulations for mid-February represent the real radiation threshold, duration of vitamin synthesis in human skin would be far less extensive table 2.0, fig. 2.2, and more in line with the vitamin D winter extent found for Boston and Edmonton (52°N, vitamin D winter about two months longer than Boston) in Webb, A. R. et al, 1988 Nonetheless, the vitamin D solutions at the centre of the experiments give the best indication of whether any pre vitamin D was formed at that time and those conditions, and not whatever the UV measurements or the FastRT model predict.

If the measurements were incorrect, and the in vitro samples were exposed to sunlight under idealized cloudless conditions as simulated by us, the vitamin D winter would indeed very extensive table 2.1, fig. 2.2. The real vitamin D winter period probably lies somewhere between those indicated in tables 2.0 and 2.1 (A. Webb, personal communication).
<table>
<thead>
<tr>
<th>Vitamin D winter</th>
<th>Minimum latitude [°N]</th>
<th>Period at 70°N</th>
<th>Cloud liquid water column threshold at 70°N (gm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear atmosphere</td>
<td>51 (74.3)</td>
<td>5 Oct. - 10 Mar.</td>
<td>2000</td>
</tr>
<tr>
<td>Low ozone (100 DU)</td>
<td>63 (85.8)</td>
<td>6 Nov. - 6 Feb.</td>
<td>&gt;4000</td>
</tr>
<tr>
<td>High ozone (500 DU)</td>
<td>42 (64.7)</td>
<td>10 Sep. - 4 Apr.</td>
<td>700</td>
</tr>
<tr>
<td>Low visibility (5 km)</td>
<td>49 (72.0)</td>
<td>29 Sep. - 16 Mar.</td>
<td>2000</td>
</tr>
<tr>
<td>High altitude (3 km)</td>
<td>52 (75.0)</td>
<td>7 Oct. - 8 Mar.</td>
<td>2000</td>
</tr>
<tr>
<td>Snow covered ground</td>
<td>53 (76.0)</td>
<td>9 Oct. - 6 Mar.</td>
<td>&gt;4000</td>
</tr>
</tbody>
</table>

Table 2.0. Duration of vitamin D winter. The right most columns are the threshold of perpetual vitamin D winter.

<table>
<thead>
<tr>
<th>Vitamin D winter</th>
<th>Minimum latitude [°N]</th>
<th>Period at 70°N</th>
<th>Cloud liquid water column threshold at 70°N (gm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear atmosphere</td>
<td>40 (63.3)</td>
<td>6 Sep. - 8 Apr.</td>
<td>400</td>
</tr>
<tr>
<td>Low ozone (100 DU)</td>
<td>55 (78.5)</td>
<td>16 Oct. - 28 Feb.</td>
<td>1900</td>
</tr>
<tr>
<td>High ozone (500 DU)</td>
<td>27 (49.8)</td>
<td>22 Jul. - 23 May</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Low visibility (5km)</td>
<td>36 (58.9)</td>
<td>25 Aug. - 19 Apr.</td>
<td>400</td>
</tr>
<tr>
<td>High altitude (3km)</td>
<td>42 (64.7)</td>
<td>10 Sep. - 4 Apr.</td>
<td>400</td>
</tr>
<tr>
<td>Snow covered ground</td>
<td>43 (66.1)</td>
<td>13 Sep. - 31 Mar.</td>
<td>1200</td>
</tr>
</tbody>
</table>

Table 2.1. Same as Table 2.0 but using a simulated weekly mean BED radiation threshold centred at 12th February 1986 (BED threshold = 3.46) for cloudless sky conditions at solar noon in Boston with a visibility of 25km and total ozone obtained from the TOMS satellite instrument. The weekly mean ozone column at this time was 388DU. The weekly mean BED was computed in order to reduce the effect of inexact dates of exposure for the 7-DHC solutions (Webb et al., 1988).
Figure 2.1. Daily period (in hours) of vitamin D production in terms of time and latitude for a clear atmosphere and no surface reflection and for a typical level of total ozone (300DU). The austral vitamin D winter is identical to the vitamin D winter at Northern latitudes.

Figure 2.2. Same as figure 2.1, but using the higher simulated radiation threshold as described in the table 2.1 legend (BED threshold = 3.46).
2.6. Vitamin D Level in Different Area

The present studies of ozone layer and UV-B radiation for synthesis of vitamin-D₃ is most useful. The studies have been done in Delhi and NCR region. In the studies, samples were taken in January, February and August 2001 in Rajiv Colony to see if there was an improvement in the post summer level of vitamin-D with ozone thickness in Dobson Unit which is shown in table 2.2. We found vitamin-D deficiency in 84% children with mean vitamin-D level 17.8 nmol/L (SD 22.4), even in the samples taken in August. We define a standard dose of vitamin D on the basis of recently recommended requirements for vitamin D that take account of its risk reduction role in a variety of diseases (WebbAR., 2006; Lokesh Tiwari., 2004).

Table 2.2 Vitamin D Levels in Slum Children, shows the number of children sampled in each area and their vitamin D levels. In Rajiv Colony, 82.9% children were vitamin D deficient with levels below 35 nmol/L (mean level 23.76 nmol/L, SD 27.03). In Gurgaon 82% children were vitamin D deficient with mean level 19.2 nmol/L (SD 20.2)

<table>
<thead>
<tr>
<th>Time of sampling (Ozone, DU) level below</th>
<th>Studies area</th>
<th>Number of children sampled</th>
<th>Mean vitamin D level (SD)</th>
<th>Percentage of children with vitamin D</th>
</tr>
</thead>
<tbody>
<tr>
<td>January (246.82)</td>
<td>Sundernagari 47</td>
<td>96.3 nmol/L (25.7)</td>
<td>2.00%</td>
<td></td>
</tr>
<tr>
<td>February (278.62)</td>
<td>Rajiv Colony 49</td>
<td>23.76 nmol/L (27.03)</td>
<td>82.90%</td>
<td></td>
</tr>
<tr>
<td>August (275.61)</td>
<td>Rajiv Colony 48</td>
<td>17.8 nmol/L (22.4)</td>
<td>84.00%</td>
<td></td>
</tr>
<tr>
<td>August (275.61)</td>
<td>Gurgaon 52</td>
<td>19.2 nmol/L (20.2)</td>
<td>82.00%</td>
<td></td>
</tr>
</tbody>
</table>
Most of the samples were taken from Sundernagari however they had normal levels of vitamin D. Only 2% children were vitamin D deficient and the mean vitamin D level was 96.3nmol/L (SD 25.7). Sundernagari and Rajiv colony are adjoining colonies and have the same amount of pollution and UV-B radiation. This suggests that the low levels of vitamin D in Rajiv colony cannot be explained entirely on the basis of pollution. Calculation associated exposure times for any time and place using either default values or user-selected conditions. Either it is not possible to synthesize vitamin D at high latitudes in winter, or the exposure time required to reach a standard dose is sometimes impractical. Where solar UV is sufficient, a risk-benefit analysis of sunburn vs. vitamin D synthesis shows that the best time for brief sun exposure is in the middle of the day. For low solar elevation angles common at high latitudes, a fine line exists between adequate UV exposure for vitamin D synthesis and a risk of sun burn. To explore the required exposure times for different conditions, including various levels of ozone, cloud, aerosol, surface albedo and surface elevation, skin exposure, desired vitamin D doses, etc. Where, user selected inputs, can be applied to the calculations. For example, we show the required exposure to obtain a dose recently recommended to gain the optimal health benefits. Interestingly, this generally require unrealistically long
exposure times for normal skin (11.5%), and would most likely cause erythematic for the exposed skin areas (not shown here). The solar irradiation intensity will be carried out at different wavelengths i.e. 290-315 nm with ozone and time of day at New Delhi. Delhi has an extreme type of climate from chilling winters to terribly hot summers. The cold season begins in November and is at its peak around New Year and half of January. After the middle of March, the weather begins to turn warm and soon it becomes very hot and from April to June one can experience extreme heat when the temperature climbs up to 45°C at times. The monsoon arrives towards the end of June. Delhi has a rainy season in winter also. It is an important season for the farmers of the union territory because the rabi crops benefited by it. Weather is generally dry except for 2-3 months of humidity. The altitude ranges of Delhi between 213 to 305 metres above the sea level.