SOME MAIN SOLUTIONS TO MITIGATE LONG – TERM CONSEQUENCES ON VICTIMS OF AGENT ORANGE/DIOXIN IN VIETNAM

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1. Introduction

In Vietnam, during the Operation Ranch Hand (1961-1971) the U.S. Army had sprayed over 70 million liters of Agent Orange containing more than 170 kg dioxin (according to some recent reports this number is up to about 600 kg) on almost all the southern part of Vietnam. The sprayed Agent Orange has seriously destroyed the environment and caused heavy consequences on human health from generation to generation during the war and even long time after the war (now it is 31 year after the end of the war).

The problem is how to mitigate the serious and long-term consequences caused by agent orange/dioxin on the environment and human health of sprayed areas and exposed people, respectively. To solve this problem it is not an easy task and it requires time and patience.

Degradation pathways of dioxin have been researched by scientists in the world, of them many are Vietnamese. Generally, it can be classified into 6 degradation pathways of dioxin as follows:

a. Volatilization in the natural environment (negligible)
b. Thermal degradation at 750 – 1200^{o}C
c. Chemical degradation (at small scale)
d. Photodegradation by sunlight or UV rays
e. Biodegradation in the body of a living organism (at low level)
f. Degradation by fungi and microorganisms.

Data from many researches provided a half-life of 15-20 years for dioxin in the natural environment. Dioxin can enter the human body through two main ways: direct and indirect exposure.

Direct exposure can be: by sprays falling directly over the human body and/or by human direct contact with contaminated water soils and trees.

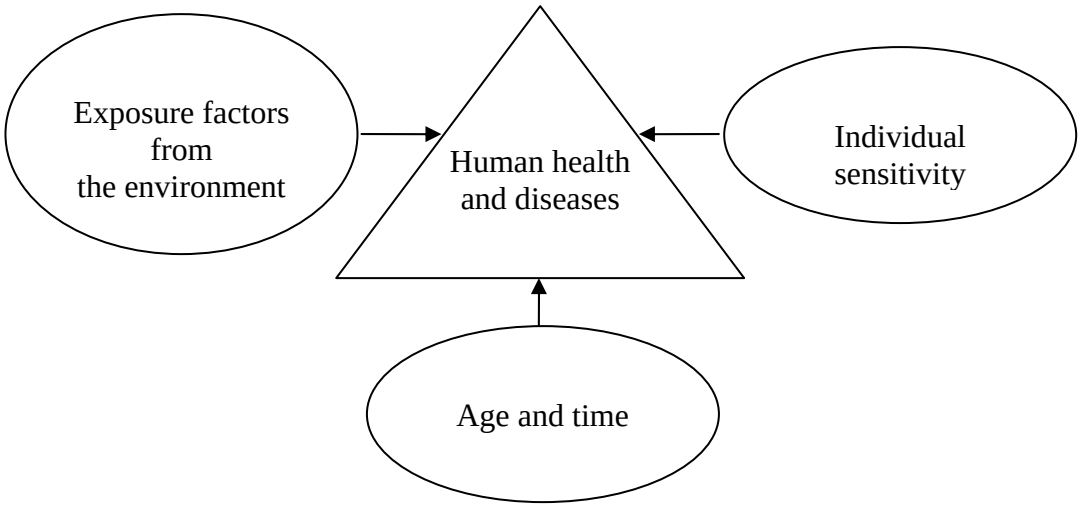
Indirect exposure can be: by human food consumption of domestic and wild animals and plants, which are already contaminated with dioxin.

Dioxin is among the most toxic substances ever known. When inside a human body, they can badly affect many internal organs and cause grave diseases on the exposed person.

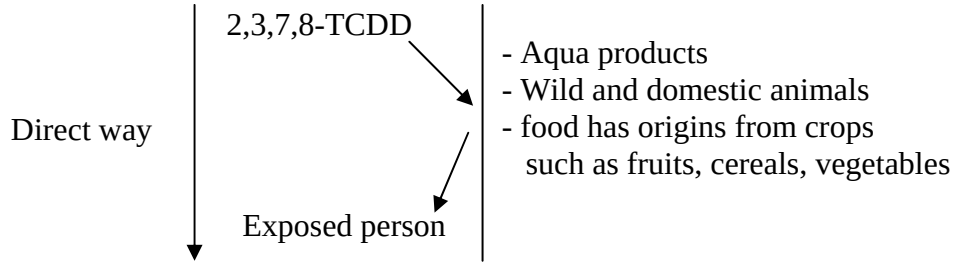
Solutions to mitigate long-term consequences caused by agent orange/dioxin on the human health should be integrated solutions that combine environment-related solutions, community-related solutions and solutions for specific diseases.
Human health and diseases are affected by three groups of factors as follows:

- Group 1: environmental factors
- Group 2: Individual sensitivity
- Group 3: Age and time

National Institute of Environmental Health Sciences (in the U.S.) described factors, which affect human health and diseases, according to the following model:



When discussing solutions for mitigation, we have to fully consider factors affecting human health and diseases, in the other hand we also have to fully look into the ways through which dioxin enter the human body. The following simple diagram is about the ways that dioxin use to enter the human body.



The solutions for mitigation must solve the following problems:

- Eliminate sources of dioxin exposure through both direct and indirect ways
- Speed up the degradation and excretion for dioxin in the body to lower the dioxin concentration in the body
- Improve the immune defense, capability of immune responses, and ability to clean up free radicals of the human body in order to overcome bad effects of dioxin on the body.
- Diagnose and specifically treat for each kind of disease that an exposed person can contract

- Society- and community-related solutions to reduce the disease burden that the exposed person and the society have to bear.

Scientific works by international and Vietnamese scientists have focused on the above mentioned groups of solutions at different levels. Group of environmental solutions (group 1) is the group that has gained many interests for research and suggested methods and technologies for environmental treatment. However, this also poses a challenge for developing countries because of expensiveness of treatment technologies that require big financial resources to be able to solve problems completely. The four remaining groups focus on human race as an object. This is a very difficult problem because of complexity in action mechanism of dioxin, thus, it is necessary to carry-out more researches in the future in order to work-out effective solutions. For the above reason, only when victims of Agent Orange/ dioxin contract (develop) a specific disease, then we can work-out a specific treatment procedure. For example, when a veteran (who was exposed to dioxin) contracts diabetes, we need to apply treatment procedures that are specific for diabetes. When a female patient (who was exposed to Agent Orange/dioxin) contracts breast cancer, we need to have a treatment procedure for breast cancer by medical operation combined with radiation and chemical treatment. However, if we wait until victims of Agent Orange/dioxin contract a specific disease then we cures the disease, it will be a very passive solution. We need solutions that can mitigate consequences at the early stage right after the exposure to dioxin of a victim, but what are these solutions? still remain a big question for international and Vietnamese scientists.

In this study, we are discussing some solutions for mitigation of long-term consequences on victims of Agent Orange/dioxin in order to provide issues that can be applied in each specific case under instructions of medical doctors. In addition to detoxification treatment for exposed victims, we should remember a very important task of preventing re-exposure and new exposure of victims to Agent Orange/dioxin in hot zones that used to be storage places for Agent Orange/dioxin or washing places for airplanes after each spraying mission during war time in the South of Vietnam.

2. Some mitigation solutions applied for victims of Agent Orange/dioxin in Vietnam

2.1. Eliminate sources of dioxin exposure

Researches on environmental residues of dioxin by Vietnamese authors and some international authors have shown that in the South of Vietnam, in some storage places for Agent Orange/dioxin left behind by U.S. Army after the war in Vietnam, levels of dioxin in soils of these places are 10.5 to 1150 times higher than the level (in the U.S.) that is considered as dangerous and needs to be detoxified. The problem here is how to prevent the continuous (long-term) exposure to dioxin for residents living around the hot zones. Many Vietnamese authors have applied some solutions to treat (detoxify) contaminated soils on-site or in laboratory.

Le Van Hong et al. used some solutions to prevent movement of dioxin to surrounding environments by isolation of the contaminated soils for treatment. Some researches by Vietnamese scientists were conducted at laboratory scale to study treatment for contaminated soils by chemical, thermal and biological degradation methods (Le Huy Du et al., Nguyen Duc Hue et al., Dang Thi Cam Ha et al., etc.). Laboratory researches have obtained initial results; and the results of the treatment methods, which showed effectiveness at laboratory scale, can be applied for on-site (field) researches.

If we can solve the problem of preventing exposure of dioxin in hot zones, we can protect residents living around the hot zones from dioxin sources. However, this work is expensive and requires advanced technologies; therefore, it is unrealistic to solve the problem in a short-time. It also requires an international cooperation to find-out solutions as early as possible. In our recent researches (Nguyen Van Tuong et al.), it has been shown that there is a new exposure to dioxin for residents living near to Danang airport, which has storage houses for Agent Orange/dioxin used by the U.S. Army during the war time.

To explain for the above phenomenon, we need to understand the movement of dioxin in the environment. It can be hypothesized that dioxin from storage tanks at Danang airport have migrated into lakes and ponds around the airport and contaminated aquatic organisms of these lakes and ponds; the residents living around the airport have caught and eaten aquatic products (e.g. fishes, shrimps) and become exposed to dioxin. Our above mentioned hypothesis was confirmed by quantitative results of dioxin in soil samples in storage tanks, in sediment samples in the lakes and ponds closed to the airport, and in liver and fat

samples of fishes caught from the lakes and ponds, as well as dioxin levels in individual blood samples taken from children living near to the airport and the lakes and ponds.

The above result confirmed that eliminating sources of dioxin exposure in hot zones is an urgent task, even when we know that this task is difficult, expensive and cannot be accomplished in a short-time. It is also important to have an education program soon for the residents living there, so that they will not consume aquatic products caught from lakes and ponds near to the airport. This education program can be implemented immediately and has a high feasibility if we really consider the danger posed by this dioxin exposure.

2.2. Speed up the degradation and excretion for dioxin in the body to lower the dioxin level in the body

Many scientific works have demonstrated that a person can absorb 2,3,7,8 TCDD (tetrachlorodibenzo-p-dioxin) through his/her respiratory tract, digestive tract and skin when being exposed to dioxin. Some research results have also shown that 2,3,7,8 TCDD is eliminated in form of metabolites from the human body together with excrement (Wendling et al., 1990). Berg et al. (1994) presented degradation pathways of TCDD based on results of in vivo experiments performed on mammals. Researches on elimination of dioxin from the body by Bickle et al. (1989), Michalek et al. (1996), and others have found a half-life of 2,3,7,8 TCDD at different values. Some authors provided a half-life of 7.1 years (Bickle et al., 1989), some provided 8.7 years (Michalek et al., 1996), some provided 11.3 years (Wolfe et al., 1994), and others provided 5.8 years (Off and Zober, 1996). The half-life of 8.78 years provided by Michalek et al. has been most accepted. Researches by Schester and Gorolwiez (1987), Furst et al. (1994) have demonstrated that 2,3,7,8 TCDD is also secreted through breast milk, and thus decreasing dioxin concentration in the body.

- Bouran (1999) calculated a value of 391 days for the half-life of TCDD in a group of female monkeys (with an error of 88 days).
- Kissel and Robarge (1998) applied the PBPK model (Physiologically based Pharmacokinetic) to study an ability to eliminate TCDD from the body. These authors estimated levels in tissues that were exposed to a background dioxin level, and elimination for 2,3,7,8 TCDD in veterans (who participated in Operation Ranch Hand) and volunteers.

It was estimated that the elimination of 2,3,7,8 TCDD from the veterans of Operation Ranch Hand (who were exposed to the background level of dioxin) was 50 pg/day. Under these conditions and according to 2,3,7,8 TCDD concentrations in fat tissues, the authors obtained the following results:

Concentration in fat tissues	**Half-life**
100 ppt	4,4 years
50 ppt	5,2 years
30 ppt	5,9 years
20 ppt	7,2 years
15 ppt	9.1 years
10 ppt	20 years

These results were in consistence with the results, obtained from studying veterans who has 2,3,7,8 TCDD concentrations in blood lipids > 10 ppt, showing a half-life of 7.1 years (Pirkle et al., 1989). The results showed that the half-life will increase considerably when concentration in tissues reaches a stable level (combined with the background level).

Vietnamese authors have begun using some pharmaceutical ingredients and some traditional ways of medical treatment, which are good for liver and bile, to increase detoxification for dioxin-exposed veterans; and the initial results are promising. Following this study trend, many scientists from South Korea, China and Japan have a tendency to find medicines, which have an origin from plants, to boost up the elimination of dioxin from the human body. Junya Nagayama et al. applied the FBRA method (food rich in fibrous substances) to reduce PCDDs and PCDFs concentrations in adult blood. The author applied a one-year FBRA for his patients and found that it was reduced by 41% of the average PCDFs equivalent and 37% of the average PCDDs equivalent in 9 blood samples of FBRA-treated patients. In blood sample of patients without FBRA treatment (non FBRA-treated patients), there are only a decrease of 34% in the average PCDFs equivalent and a decrease of 29% in the average PCDDs equivalent. The author believed that FBRA help increased the elimination of PCDDs and PCDFs. Professor Takaolida has researches focusing on the excretion of dioxin from the body and suggested that this method is the

most effective. Due to its lipophilic characteristic, in the body, dioxin accumulates much in fat tissues. Some authors tried to make the dioxin-exposed patients drink vegetative oils at a specific dose. These authors hoped that in the renewal process for lipids in the body, an excessive lipid amount to be excreted via the digestive tract would bring together it a considerable amount of dioxin. In detoxification, it is important to cure a victim at the acute stage when he/she is initially exposed. However, all victims of Agent Orange/dioxin have passed the acute stage, therefore, detoxifying at the chronic (long-term) stage is a very difficult task. Moreover, dioxin has a very long half-life and accumulates mainly at fat tissues; therefore, re-mobilization of accumulated dioxin into blood for its excretion needs to be studied too. One way to detoxify a toxic substance in the body is the excretion via sweat. Applying this detoxification mechanism, many authors have applied a sauna method combined with drinking vitamins, oils and doing exercise to increase elimination of toxicants via sweat. Dioxin can also be eliminated from the body by the above method (detoxification method by Hable).

2.3. Improve the human health and immune defense, capability of immune responses, and ability to clean up free radicals

Researches on human beings have found clear evidences about bad effects of CDD on the immune system (Formest et al., 1998; Jarsing and Kroff, 1994; Jung et al., 1998; etc.) However, researches on animals have shown that CDD are immune inhibitors (Kerkviet, 1995). 2,3,7,8 TCDD caused depletion in the weight of thymus gland when a person is exposed to dioxin via the drinking way (Hanberg et al., 1989; Meconnel et al., 1978). Hong et al. (1989) found damages in the marrow of the monkeys that were exposed to 2,3,7,8 TCDD orally.

Usage of traditional medicines and pharmaceutical ingredients is effective in positively stimulating the immune system, and in enhancing ability for immune responses of cells. This can be good solution for detoxification. Some Vietnamese scientists have been testing on experimental animals following a study trend that focuses on application of Vietnamese traditional medicines to stimulate the immune system and/or to enhance an ability to clean up free radicals formed in the metabolism of 2,3,7,8 TCDD.

Nguyen Thi Ngoc Dao et al. used a synthesized product called Naturenz, which is a mixture of vegetative enzymes, natural anti-oxidants, amino acids and vitamins. Naturenz is effective in increasing levels of the free –SH group, total Hem content, and Aniline hydroxylase activity in blood and serum of patients. Naturenz improves liver function, and makes a better health for the patients. Following this study trend, authors from Japan, South Korea and Vietnam have worked-out many medicines of plant and animal origin, which enhance the immune adaptability, immune defense, and ability of anti-oxidation. This group of solutions does not have any direct effects on detoxification, which eliminate dioxin from the body, but it has indirect effects through generally helping the human body defense against toxic consequences at both cellular and body scale.

2.4. Diagnose and specifically treat for each kind of disease that an exposed person can contract

Based on investigation of hundreds of scientific works relating to dioxin from early 1970s to the end of 1999, American Medical Academy officially proclaimed that some diseases have clear evidences relating to dioxin, some diseases have limited evidences of relationships to dioxin and other diseases have insufficient evidences. Annually, from obtained research results, American Medical Academy has published dioxin-related diseases. Some diseases with clearly confirmed evidences relating to dioxin include:

- Soft Tissue Sarcoma
- Lymphoma non-Hodgkin
- Hodgkin
- Chloracne

Some diseases are considered as having evidences of relationships to dioxin include:

- Respiratory tract cancers (e.g., lung cancer)
- Prostate cancer
- Multiple myeloma
- Spina Bifida
- Porphyria cutanea tarda
- Disorders in external neural system
- Diabetes

For some other diseases, there are not enough evidences to state that they are involved by dioxin. At the International Conference on Dioxin in 2000 and 2001, scientists presented some results on the involvement between exposure to dioxin and some diseases. Solutions (for reducing disease burden)for dioxin-related diseases and non dioxin-related diseases face many difficulties because first of all we have to determine the dioxin exposure, and then determine related factors and eliminate contamination factor. However, solutions of medical treatment according to specific diseases are inevitable. Regardless a disease is dioxin-related or non dioxin-related, the attitude of a medical doctor toward his/her patients must be to devote his best for the treatment of patients. In this paper, although treatment solutions for non-specific detoxification are mentioned more, but if we do not mention about problems of the treatment according to a specific disease, we will make the readers misunderstand (or understand with more priorities) the solutions of health care for victims of Agent Orange/dioxin.

2.5. Society- and community-related solutions to reduce the disease burden that the exposed person and the society have to bear. This is the group that very early gained interests of Vietnamese scientists.

Media should be used to help broadening knowledge of the general population. The people will know how to protect themselves when being contacted with the environment and when consuming food and water, etc.

Functional rehabilitation based on community helps children with birth defects being cared more carefully. Hoang Dinh Cau et al. at Committee 10-80 helped build “Hoa Binh” (Peace) village systems to care for the children suffering birth defects who have their mother and/or father were exposed to dioxin during the war time. With supports from international organizations, and humanity organizations, from 1971 to 1999, Vietnam has invested for building 113 health centers at commune and ward level for 53 provinces and cities; and it will continue building more local health centers to (1) diagnose and treat for victims of exposure to dioxin during the war and (2) provide general health care for local people.

Vietnam government has policies to support victims of Agent Orange/dioxin by providing monthly subsidiary money, health insurance, and many support programs such as "to eliminate hunger and reduce poverty " program, " to mitigate the pain caused by Agent Orange" program, and "to support victims of Agent Orange/dioxin" fund, etc.

Although the above social and communal solutions have no effectiveness on the detoxification, as well as enhancement of body immune defense, they are effective ways to support the victims psychologically. By consolidating psychologically, the solutions help the victims overcome burdens on their diseases, on their family and descendants, all of these burdens are daily influencing feelings and sentiments of the victims.

3. Conclusion

Diseases caused by U.S. Army's Agent Orange/dioxin, which was sprayed during Vietnam War are not only complicated and difficult health problems, but also widespread social problems; and they are heavy burdens for Vietnam nowadays and in the coming several tens of years of the 21st century. Finding solutions to eliminate the sources of dioxin exposure to the human body in some hot zones is an urgent task in order to prevent re-exposure to dioxin for the population living around the hot zones. Similarly, finding solutions for increasing the elimination of dioxin from the body, for detoxification, for enhancement of human health, and for reducing disease burdens is also a very difficult task, but worth to invest and research; and it is necessary to establish a wide cooperation between Vietnamese and international scientists to solve the problems of dioxin timely.

In non-specific detoxification solutions, which are mentioned in this paper, there are solutions that are not only applied specifically for victims of Agent Orange/dioxin, but also applied for other human objects (patients). The action mechanism of dioxin in the human body is a very complicated mechanism and at molecular scale. Consequences caused by the mechanism on the human body are not specific, thus, it is not possible to point them out exactly. Instead, we can only mention some diseases with certain or uncertain relationships with exposure to dioxin.

For the above mentioned reason, the view on solutions for mitigation of long-term consequences caused by Agent Orange/dioxin must be an all-sided view; and it must combine mitigation solutions for both the human health and the environment.

Recently, we have done many things for the victims of Agent Orange/dioxin. However, due to limits of resources (e.g., human and financial resources), lacks of experiences, works to mitigate long-term consequences on the health of the victims of Agent Orange/dioxin are still so urgent, heavy and difficult works that require bigger investments and wider scientific international cooperations in order to accomplish.

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