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Chemical Warfare

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Abstract-

Chemical warfare is one of the most appalling and destructive types of warfare in which various types of deadly and toxic chemicals are used as chemical weapons. These chemical weapons containing CWAs have very terrible and long-term negative effects on humans, animals and the environment. Many times in history, these chemical warfare agents are prohibited by various treaties. However, it is very difficult to ban all CWAs because of their industrial applications. This chemicals may be misused by militant organizations, or nations without nuclear power, as chemical weapons. These CWAs, which could be misused as chemical weapons, will always remain a threat to public security and global security. In this review, we will briefly discuss about chemical warfare agents and their types, physicochemical properties and their effects on humans and the environment.

1. INTRODUCTION-

Wars have been an important part of civilization since ancient times. There has also been a shift in the ways, tactics and strategies of war due to transition in environment, technology, economy, climate, politics, values / cultures with time. There were periods when innovations enabled armies to generate new concepts of war; and periods when new concepts were required to introduce new technology. In each of these cases, the armies tried to respond to evolving warfare characteristics through strategic research and development (R&D), which is called "Change in Military Relations". [1]. So various types of warfare came into existence. Chemical warfare is one of them too. Chemical warfare is the use of chemical substances having poisonous properties to attack, damage or destroy an enemy during the war, and these are related to military operations [2].These chemical warfare agents may have deadly effects on human bodies. CWAs are synthesized compounds that can have a strong harmful effect on humans, animals and plants. Usually, CWAs poisonous substances are capable of rapid failure, sudden death, and permanent adverse health effects [3].

[For the purposes of this article, chemical agents are chemicals that present exceptional lethality and danger to humans [2]. Some chemical agents are toxic industrial chemicals that are used for commercial purposes, while others are chemicals that are primarily produced as weapons [44]. At the very outset, chemical warfare was more intimately related to flames. "Greek fire" was a marvellous maritime weapon as it would glide over the sea and set fire to wooden warships. There are many notable examples: in the year 2000 BC in China, for example, poisonous smoke was used.

In The history of the Peloponnesian War in Thucydides,[45]the conflict between Athens and Sparta in the 5th century BC, the first account of chemical conflict - production containing poisonous sulphur oxide by burning sulphur is found in. Hannibal of Carthage used poisonous snaked baskets against his opponent in the year 184 BC. The arsenic-containing Aqua Toffana has also been a famous poison in ancient Italy. In the 15th century [Leonardo da Vinci] [45] suggested a compound of arsenic sulphide [4].In the 17th era the first recorded treaty to prohibit war poisons was signed between the French and the Germans. In the Groningen siege, European armies used explosive devices to unleash belladonna, sulphur, and other substances. This led to the Treaty of Strasbourg in 1675. This contract banned poison bullets. In 1874 the Brussels treaty on the Rules and Customs of War outlawed poisons or guns connected with poisoning [5].Only, French soldiers used ethyl bromoacetate in WW1. Followed the use of o-dianisidine chlorosulphonate, chloroacetate, arsenic, phosgene, hydrogen cyanide, ammonia, diphenyl chloroarsine, ethyl and methyl dichloroarsine and sulphur mustard, resulting in nearly 10,000 deaths and more than one million injuries.[46]During the WW2 the chemical weapons agents (CWA's) were not used since the opponent had much more lethal CWA's than the Nazis who utilized them for the Jewish massacre in the notorious gas chambers.[2]CWA's were used intermittently during the Second World War, both in fighting and in acts of terrorism[2].In the 1980s, Iraqi's use of CWA's led to thousands of losses in the Iran-Iraq Conflict. It is estimated that during Operation Desert Storm around U.S government troops 1, lacs maybe CWA's were exposed. International legal pressure has been applied to ban the use of such CWAs because of the adverse effects of chemical warfare. First Hague Conference in 1899: Prohibiting the use of poisons. "The contracting authorities decide to refrain from using projectiles whose primary intention is the dissemination of asphyxiating gases." Second Hague Conference, 1907:Prohibition of First Assembly toxins is maintained. In Washington senate in 1922: representatives from the United States, Britain, again the United Kingdom, Italy and Japan vote to prohibit the use of asphyxiating, toxic and some other gases [6].France declined to overturn and the Agreement had never entered into force. Protocol of 1925 to Geneva(city in Switzerland) : Convention on the "Prohibition of the Use of Asphyxiating, Poisonous or Other Gasses in Warfare and Bacteriological Methods of Warfare"[6].During 1992, the Geneva(city in Switzerland)-based Demilitarization Committee accepted the Regulation on the Banning of the creation, Manufacture, Stashing, and Availability of nuclear weapons and their weapons of mass destruction Removal Agreement. On 13 January 1993 the CWC opened in Paris for signature. This entered into force on 29 April 1997 as a international legal act with 87 States parties. Now, 192 countries constitute 98 per cent of the world's Population and but four UN nations have not yet been related to it: Syria, Jordan, The Korean People's Democratic Republic, and South Sudan. As of April 2016, an72 525 metric tons of chemical agents were depleted by 90% of the world's stock [7].The manufacture of such CWA's cannot be restricted due to essential Factory utilizations. Particularly from those nations which don't have nuclear power, these agents are still at danger because they are easy to produce, inexpensive and have devastating impacts. Those substances can work in terrorist acts [2]. The 1995 Tokyo subway attack by Aum Shinrikyo used sarin (GB) gas which resulted in hundreds of wounded people and 13 deaths. In 2013, GB was used against a civilian population in the Damascus area of Syria, resulting in the deaths of about 1400 people, thousands of others being wounded[**8**].Consequently, abuse of these CWAs will still remain a threat to national security and to all nations. According to the North Atlantic Treaty Organisation (NATO), CWA's are known as nerve agents, blister agents, asphyxiants, shock agents and disabled / behavioral alterers [**2**].In this article, we will discuss about the chemical warfare agents by explaining their historical events, classification, destructive effects on humans as well as environment, detection, decontamination, detoxification, clinical features on exposure and treatment.

Classification of CWA's

Chemical warfare agents were categorized into a variety of groups, based on their human influence. Categories include nerve, blister, coughing, vomiting, blood, tear, and incapacitating, with the most important categories of nerve and blister agents in terms of military use and historical usage.CW agents were categorized in many ways. They can be grouped at reasonable concentrations simply by their prevailing gross effect: lethal, tissue-damaging (casualty-producing), annoying (harassing), incapacitating .Instead, they may be more precisely categorized according to their main physiological effects: vesicants (blister agents), lung injuries (choking agents), blood agents, nerve agents, irritants (skin, eye and respiratory), and disabilities. A third type of classification of agents is based on their physicochemical properties: non-persistent (moderate to high volatility), persistent (low volatility) [9].

Physicochemical Properties

[Physicochemical properties are a significant determinant of an agent's hazard (as opposed to toxicity), and thus the most likely form of usage. Despite widespread use of the words mustard gas, nerve gas, etc., most CW agents are liquids. Efficient transmission is essential for a chemical weapon to be successful. Regardless of the property of the agent, it needs to be uniformly distributed over the target area. Non-persistent agents (e.g. sarin, phosgene, and HCN) have moderate to high vapour pressure and vaporize readily; at ambient temperatures, the least persistent are gasses. The key entry point is the heart, though the eyes may be essential as well. Non-persistent agents were disseminated using adapted standard ammunition as a mixture of vapour, aerosol and small droplets, depending on their vapour pressure and the dissemination energy used. Arin is the primary non-persistent agent; inhalation effects begin in minutes. Such an agent is also appealing to terrorists because compared to persistent agents, it is easier to disseminate. The most toxic non-persistent chemicals, such as phosgene, chlorine, and HCN, are commonly considered redundant because successful concentrations over a modern distributed battlefield will be difficult to attain. Effectively they could be used against vulnerable civilians. Persistent agents have low vapour pressure, and most contain inadequate vapour concentration by inhalation to cause large numbers of casualties. The key entry point is through the skin. The onset of effects is sluggish (up to several hours) by this route of exposure with the most significant persistent agents, i.e. sulphur mustard and V-agents. When aerosolized, the most possible application of a persistent agent is droplets to contaminate the ground and facilities, rear storage locations, and supply routes. They are primarily aggressive against well-protected and skilled staff, pushing defenders into individual protective gear, followed by forced physical, physiological and psychological impositions, along with impaired communication. The most effective persistent agents have some resistance against degradation of the environment. Based on the environmental conditions (temperature, wind, and precipitation) they can remain on the battlefield for days or even weeks.28 Wet and windy conditions can minimize persistence from days to hours. Decontamination is mainly targeted towards persistent pathogens. Of course, there is no simple demarcation between persistence and non-persistence, with a gradient of variability over a broad range, and a heavy dependency on the ambient temperature. Chemicals with intermediate volatility can be highly efficient, with sulphur mustard being the prime example. Depending on the environment, sulfur mustard can create enough vapour to cause damage by inhalation, exposure to the eyes and contact with moist sensitive areas of the skin, but when present as droplets it can pose a constant contact hazard on the ground. So man is far too volatile unless thickened to be an effective intermediate volatility agent (IVA), but the less volatile cyclosarin (GF) and 2-methyl GF fall within the intermediate volatility range. Boiling points and volatility of the main agents at 25 ° C are shown in Table 1.2.49 Volatility is characterized as the maximum concentration of vapour in a confined space and at a given temperature in equilibrium with the liquid agent; it is derived from data on vapour pressure. Just a small percentage of this interest would possibly be obtained in an open space such as a battlefield. Volatility is highly temperature dependent, with a rise of 10 ° C above 20 ° C approximately doubling volatility. Other physical characteristics are important too. The volume of spread (e.g. oil versus water) is determined by surface tension. Most liquid CW agents are similar to organic liquids or oils, which have a much lower surface tension than water. They continue to grow on surfaces, getting into hard-to-decontaminate sections with water-based decontaminants. Viscosity determines the thickness, the ability of an agent to adhere to surfaces, and the size decreases upon dissemination [9].

Solid agents

Solid agents are a special case in that they are usually distributed as aerosols, small particles with particle sizes in the respiratory range (1–10 μm diameter).48 Particulate aerosols are produced most effectively, either thermally or pneumatically, targeting the lung as the primary entry portal. The use of numerous pyrotechnic sub-munitions is one of the most powerful and effective ways of disseminating solid agents. The agent is combined with a pyrotechnic mixture, vaporized at high temperature rapidly (within seconds) and instantly condensed in cold air to a particulate aerosol[9].

COMMON CHEMICAL WARFARE AGENTS

1. Nerve agents
2. Blister agents
3. Choking agents
4. Blood agents/Asphyxiants
5. Incapacitating agents
6. Tear agents
7. Vomiting agents

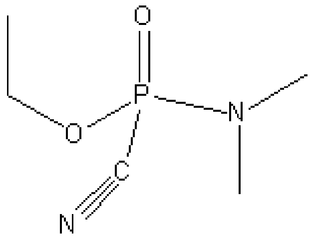
1. *Nerve Agents-*

Nerve agents serve as derivatives based on organo phosphorus (OP) as well as the most commonly known harmful chemicals.OPs develop their poisonous impacts through permanent activation of the neurotransmitter acetylcholinesterase, an enzyme that breaks down acetylcholine. Aggregation concerning acetylcholine in which neuromuscular junctions are triggered in reaction to OP treatment and nerve synapses to over-stimulate cholinergic receptors, which may contribute to muscular fatigue, excessive secretions, respiratory distress, epilepsy, coma, and ultimately death from respiratory and/or cardiovascular failure or seizures[10].

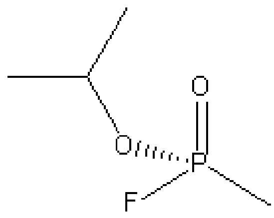
Chemicals known as nerve agents interfere with the normal functioning of the nervous system. Naturally there aren't nerve agents. Rather they are manmade compounds that require high purity and toxicity to be produced and isolated. Many nerve agents are in a category of chemicals that are called organophosphates.[44]

Types of nerve agents-

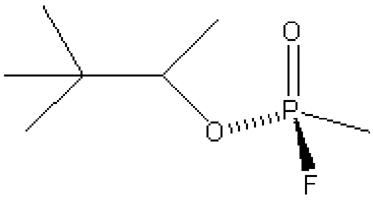
OP nerve agents are usually referred to deadly CWAs known to classified as members of series "G" or "V." G-agents are unstable and non-persistent, accompanying tabun (O-ethyl N, N-dimethylphosphoramidocyanidate; GA), soman (O-pinacolyl methylphosphonofluoridate; GD), sarin (isopropyl methylphosphonofluoridate; GB) as well as cyclosarin (cyclohexyl methylphosphonofluoridate; GF)(Figure 1)[11].



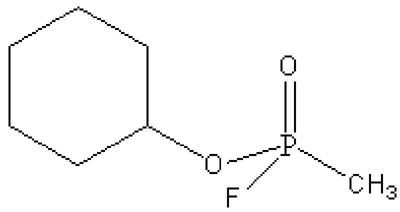
A.Tabun



B. Sarin



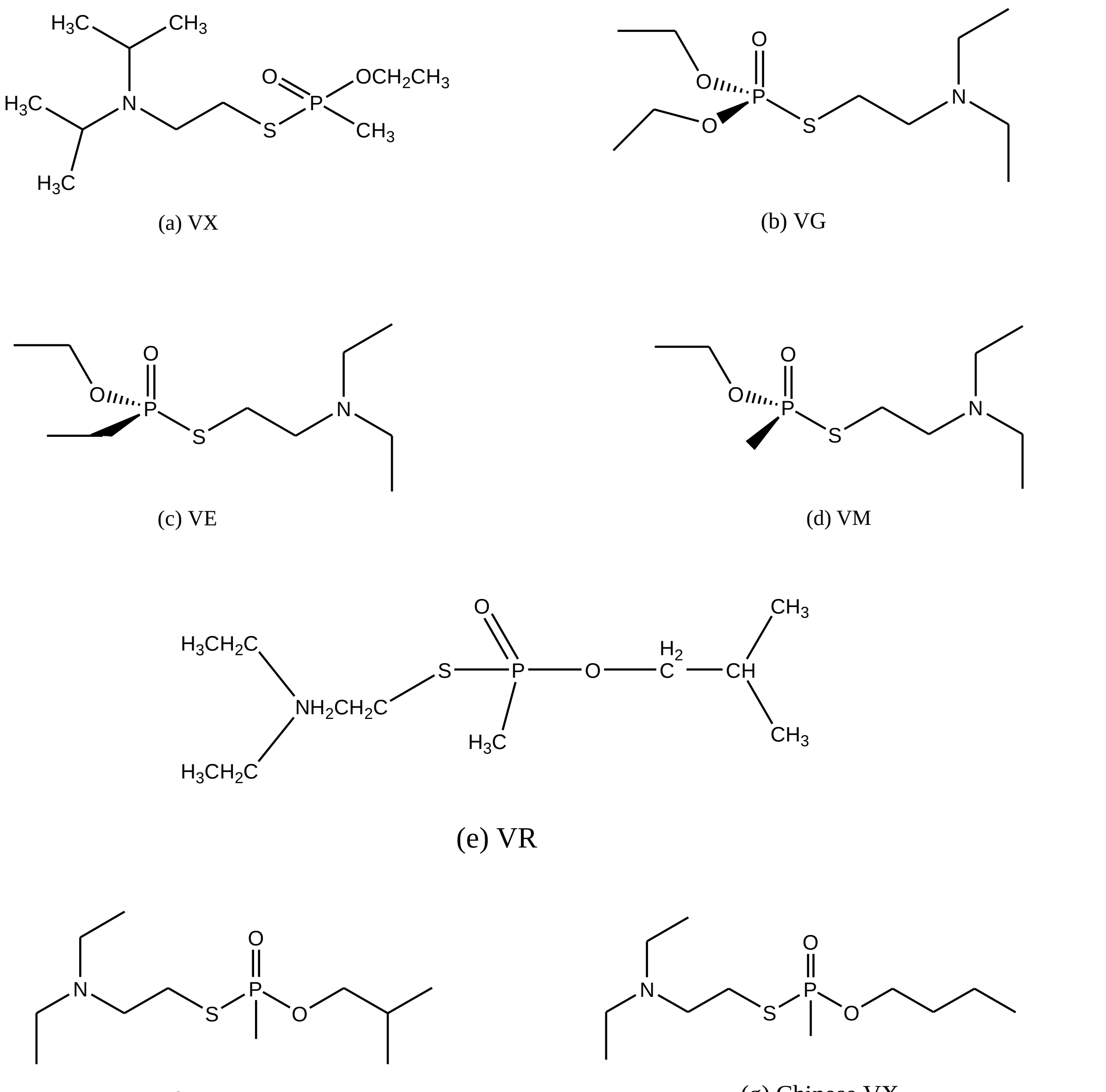
C. Soman



D. Cylosarin

Fig. 1. Structures of G-series nerve agents

The substances were so called in commemoration of Dr. Gerhard Schrader and his associates, and the 'G' was meant to define the series in each German term in appreciation of the nationality of Schrader as well as his colleagues.Within this series, the odor of various means is usually characterized as 'low fruity' or 'spicy.'In the 1950s, scientists in the United Kingdom synthesized another form of nerve agent known as the V-series as pesticides.The agent name of the V-series refers to the 'venomous.' The agent is less volatile as well as strong durablity; thus, they can persist on clothing as well as on other substances even after operation. The 5 forms of chemicals listed in the V-series are VX (Oethyl – S–[2(diisopropylamino) ethyl] methylphosphonothioate, VE (O-ethyl-S-(2-diethylaminoethyl) ethylphosphonotioate), VG (O, O-diethyl-S-(2-diethylaminoethyl)-phosphorotiate), VM (O-Ethyl S-(2-(diethylaminoethylmethylphosphorotioate) as well as VR S-[2-(diethylaminoethyl] O hydrogen methylphosphonothioate.[3] (Figure. 2).
The V-series OP CWAs are made of phosphonothioates say, VX, VE ,VM along with phosphorothioate VG (amiton) that varies structurally in comparison to the established chemical warfare agents concerning G-series nerve agents.The OP CWAs related to the V-series are highly active and fast-acting inhibitors of acetylcholinesterase, and are among the most dangerous substances ever synthesized on a wide scale [12,47]
Independently of the United Kingdom and the United States, a well-known Russian VX isomer (VR, RVX, Substance 33, S-[2-(diethylamino) ethyl] O-(2-methylpropyl) methylphosphonothioate) was developed by the Soviet scientists.[48] It was later a version of the NOVICHOK agent series. The other structural cogener based on VX referred to as Chinese VX (CVX, O-butyl S-[2-(diethylamino)ethyl] methylphosphonothioate , Fig. 2) synthesized and researched, as well[13].[



(a) VX (b) VG (c) VE (d) VM (e) VR (f) Russian VX (g) Chinese VX

Fig. 2. Structures of V-series nerve agents]49

2. *Blister Agents-*

Mustard agents' corporates DNA as well as protein alkylating chemicals that can trigger short or chronic impacts such as cytotoxicity, mitosis inhibition, mutagenesis,carcinogenic effects as well as colinomimethic impacts. Because of the greater effects the dosage levels related to mustard agents prescribed by the Center for Disease Control and Prevention (CDC) is 0.7 mg / m3 and is Instantly Dangerous to Life or Health (IDLH) [14,50] The blister agents include mustard for sulfur, mustard for nitrogen and lewisite.

Sulfur Mustard-

Sometimes named as mustard gas. It was synthesized by Despretz in 1822, and by Niemann & Gathrie in 1860. Pure Sulfur mustard is colorless and odorless. It is a lipophilic liquid with low aqueous solubility and yet is highly soluble in organic solvents. Its color varies from light yellow to dark brown, with garlic, horseradish, or mustard smells [15].Firstly, it was used in 1917, near Ypres, Belgium, as a CW agent, Whose French name comes from this place(Fig. 3). [Mustard is 2,2'- di(chloro-ethyl) -sulphide. In German it is recognized by the tag "Lost"[51,16].

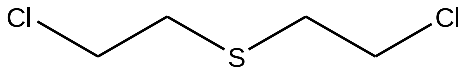


Figure3. Yperite [HD]

Nitrogen Mustards-

Three amine derivatives consist of the HN-1 (bis(2-chloroethyl)ethylamine), HN-2 (bis(2-chloroethyl)methylamine) as well as HN-3 (tris(2-chloroethyl)amine) both are set of blistering nitrogen agents (fig. 4).HN-1 was originally produced for medical purposes around 1920s as well as known to possess some explosive effects in proximity of sulfur mustard (bis(2-chloroethyl)sulfide or HD) and lewisite (dichloro-(2-chlorororvinyl)arsine.HN-3 has some toxicity symptoms identical with HD, except HN-3 possess severe lacrimatory symptoms and induces fast body rash[17].

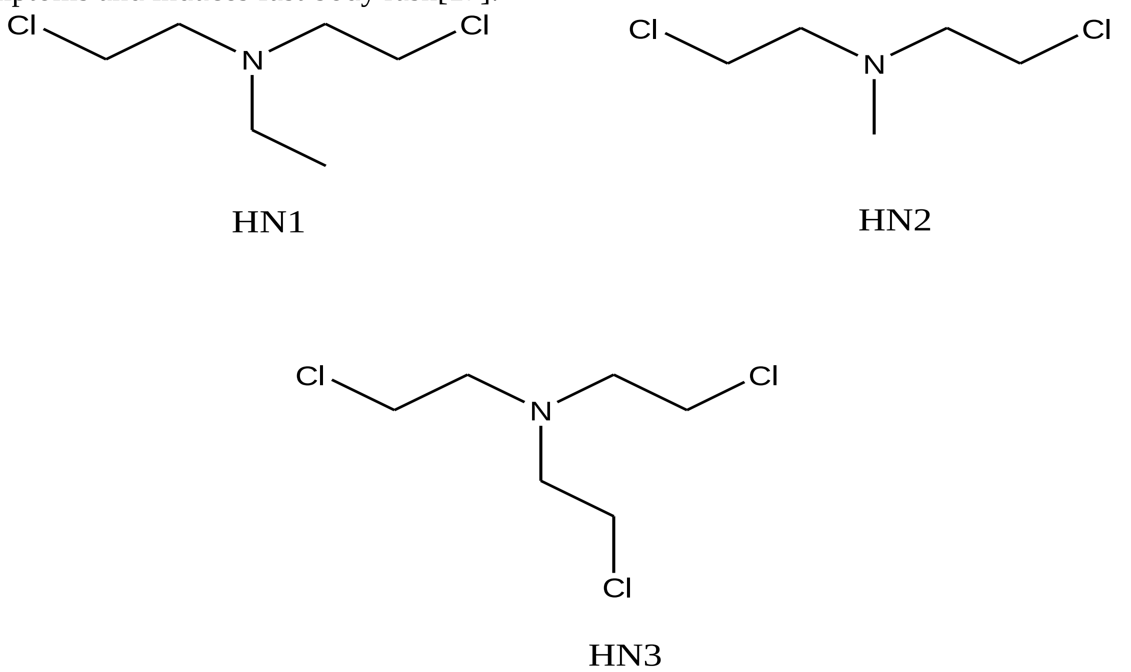


Fig 4. Structures of Nitrogen Musterds, (a) HN1, (b) HN2, (c) HN3.

Lewisite-

D2-Chlorovinyldichloroarsine was discovered, known as Lewisite or L in 1903 afterit was rediscovered as a chemical weapon in 1918 by a committee led by Captain Lewis of the United States Army Nuclear War Services. [18].Lewisite (L) is a potent blistering agent / resicant for dichloroarsin. Pure lewisite preparations are colorless and odorless oily liquids but they can have a fruity or geranium-like odor if the preparations contain impurities. Lewisite penetrates rubber as a material, and most fabrics. As a liquid it is typically more harmful than as a vapour. If lewisite survives for an extended period of time in the atmosphere is uncertain, but it can react with water in a way that loses its volatility and much of its blistering strength [19]. The structure of Lewisite is given in the fig 5.

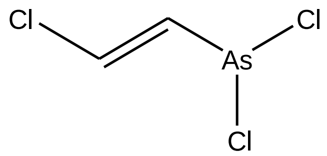


Fig 5. Lewisite

3. *Choking Agents-*
Historically the term choking defines those chemicals devices that are lung-damaging agents. For instance, phosgene (CG), diphosgene (DP), chlorine (CL) along with chloropicrine (PS). Phosgene is responsible towards 80 per cent of all chemical casualties in the First World War. In addition, 14 various breathing agents such as obscure (smokes), annoying agents (chloracetone) and vesicants (mustard) were used which may inflict damage to the lungs [20].

Chlorine Gas-
Fritz Haber (born December 9, 1868, died January 29, 1934) was a German chemist and Nobel prize winner, who first suggested the German army to use chlorine gas as a chemical weapon. It later gave him the "father of chemical warfare" nickname. Chlorine evaporates at -34 ° C at 760 mmHg, as well as present in a natural atmosphere in gaseous form. This is greenish-yellow and has a distinct scent because it is clear and amber-coloured as a drink. Chlorine gas has a medium solubility in water, rather than other fast-acting irritant gases such as ammonia or acrolein[21].

Phosgene-
Phosgene at standard conditions is a colourless gas. Carbon monoxide with chlorine gas when reacts in the presence of activated charcoal forms phosgene. Phosgene favours to produce isocyanates, polycarbonates, pesticides, dyes, and pharmaceutical products. It was developed in 1812, which later utilized in chemical warfare agent during the First World War. Phosgene gas can be collected in sub sided regions due to its higher density relative to air; hence, thick pockets in battle trenches caused significant exposure during the First World War. Germany has utilized phosgene gas as a nuclear assault weapon opposed to the British soldiers during the First World War [22]. The structure of phosgene is given below in fig. 6 [23].

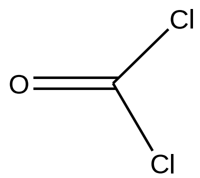


Fig 6. Phosgene

Chloropicrin-
Chloropicrin, or trichloronitromethane, referred to as highly volatile, colourlesswith lower viscosity (bp 112 ° C) (1,65 × 10^5 mg m^{-3} at 20 ° C). It was synthesized using an aqueous solution of picric acid and bleaching powder. It has been seen as a lachrymatory agent and

deadly gas on a wide scale in World War I.It caused vomiting as the soldiers inhales and were forced to remove their helmets to open themselves to gasses less easily penetrated helmets. It has also been mixed with other harmful substances, specially phosgene and diphosgene. It has low water solubility, 0.16% at 25 ° C, typically breaks down rapidly in soil having half-life of approximately four hours.[24]. The structure of Chloropicrin is given below as:

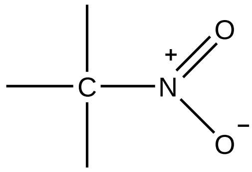


Fig 7. Chloropicrin

4. Blood Agents Or Asphyxiants-

Asphyxia is characterized as an deficient or absent ventilatory exchange of oxygen and carbon dioxide; hypercapnia combined with hypoxia or anoxia combined. Stedman's further describes an asphyxiant as "anything, especially a gas that causes asphyxia." Although people prefer to think of highly poisonous gasses when addressing asphyxiation, it is especially important for emergency physicians to bear in mind that asphyxiants can be gasses, liquids or solids and can potentially enter the body not only by inhalation but also through skin absorption, swallowing [25].Blood gases or agents commonly block different enzyme processes, essentially attacking red blood cells for their effects. They induce widespread hemolysis that contributes to hemoglobin release in the urine. Coagulated matter gathers in the tubules of the kidney, causing eventually renal disease, anuria, and uremic death. Even the victim gets chills, nervousness, fatigue and breakdown. Hydrocyan acid gas (HCN) is a well-known example of a blood gas [26]. HCN, Cyanogen chloride and Arsine are the important blood agents which are used as chemical warfare agents.

Hydrogen Cyanide-

Cyanide is known as hydrogen cyanide (HCN) in a gaseous state. This is known as hydrocyanic acid/prussic acid as well ascyanogen in liquid form.It is HCN water solution of either 2 or 4 per cent.Pure acid is a colourless, acidic substance with a metallic scent. Ships are fumigated with HCN gas.This is also used in a number of laboratory methods and in the fields of sculpture, galvanizing, metal colouring, steel / iron case hardening and tanning [27].Higher doses result in stiff or dilated legs, hypoxic convulsions, unconsciousness, muscle incoordination, paralysis, heart attacks and respiratory failure.According to the National Institute for Occupational Safety and Health (NIOSH), HCN's allowable and recommended susceptibility limit is set atFor TWA (average time-weight) 10 ppm (11 mg / m3) and 4.7 ppm (5 mg / m3), respectively). The approximate limit for risk is set at 50 ppm [28]. It has linear structure.

Cyanogen Chloride-

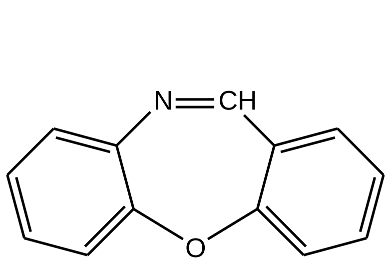
Cyanogen chloride was synthesized in 1787 using chlorine activity on hydrocyanic acid (aka prussic acid) called oxidized prussic acid and in1815 cyanogen chloride was discovered.It was used in the First World War. Cyanogen chloride has been used as an alarm agent in fumigant gasses for chemical synthesis (military poison gas) andMetal cleaner (in mineral or synthetic rubber production) as a tear gas, and also for glazing and lighting. Due to cyanogen chloride's alarm properties, it was used a lot as a pesticide in the past.Cyanogen chloride is extremely reactive, and it easily hydrolyses in the environment [29]. Cyanogen chloride also has linear structure.

Arsine-

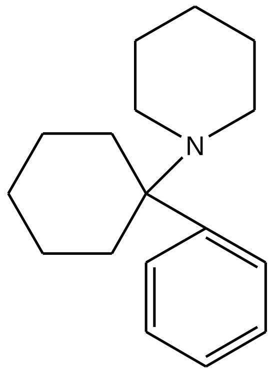
Arsine is a colourless substance used for semi-conductor synthesis, with a slight scent of garlic. At small concentrations it is heavier than the air and deadly. The inhalation of arsine usually induces physiological symptoms after 4-6 hours in humans. The signs include headache, fatigue and vomiting. Large hemolysis is the main cause contributing to anemia. Hemolysis is thought to be caused by hydrogen peroxide formation and oxyhemoglobin adducts or contact with the sodium-potassium pump, swelling of red blood cells which leads to bursting. Renal failure, the urine is dark red, is common. Pulmonary collapse will happen [30].

5. Incapacitating Agents-

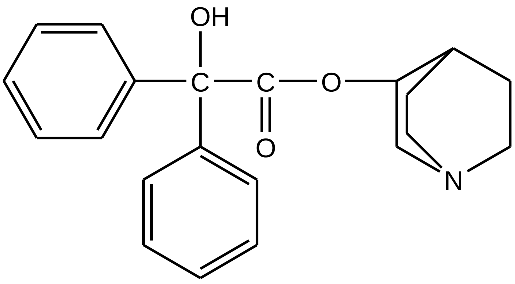
Incapacitating agents comprise any drug, chemical or biological force capable of intervening temporarily and non-lethally with the capacity of humans or animals to perform normally, either at work or in the course of everyday life tasks. The production and manufacture of these agents has in the past been generally limited to centralized governments, as has their treaty control and decommissioning. Because of the sheer number and reach of possible targets, the ability for rogue states, militant organisations and offenders to exploit, doctors need to be alert to emerging threats. Incapacitation is approximately equivalent to the word "disability" used in clinical medicine and used in a general context and signifies the failure to perform a strategic or operational task due to a quantifiable physical or psycho behavioural deficiency (US Army Medical Research Center of Chemical Defence) [31].NATO [North Atlantic Treaty Organisation] describes incapacitating substances as chemical agents that induces short-term crippling effects that may be physical or emotional, which can continue for long days even after the its exposure. Although not normally needed medical attention encourages a quicker recovery. A number of chemical compounds became the focus of the military research performed in the 1960s through the 1980s, and the possible options became incapacitating substances. The outcome of this work was a single chemical agent, 3-Quinuclidinyl benzilate, BZ agent, which was developed in the early 1960s as a psychoactive chemical warfare agent [32].Nowadays incapacitating agents are often by police. These are classified into irritants and psychochemical factors according to the rate of ingoing effect and reaction syndrome. The five compounds CR, PCP, BZ, C and F are of military importance.Two of them (CR, C) are riot liquidation agents (riot control) that also form successful charge of different defence police that counter-terrorist weapons. The remaining three are psycho pharmaceutical compounds: BZ is regarded as a chemical agent that has also been used in the Vietnam War. PCP and F are anaesthetics and anticonvulsants that have a huge head and shoulders effect over morphine. In the operation of Russian special forces at the Moscow Theater Dubrovka in October 2002, F was used as antiterrorist weapons in the form of aerosol. PCP is used as a drug [33]. The structures of these five compounds or chemicals are given below in (figure. 8).



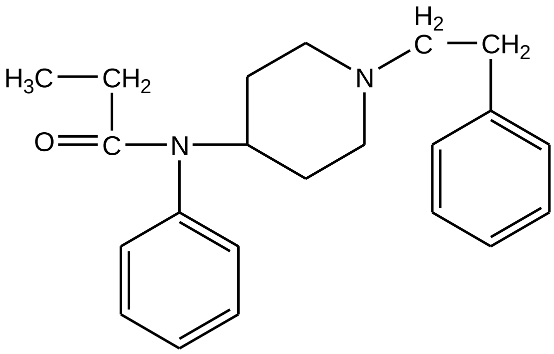
CR



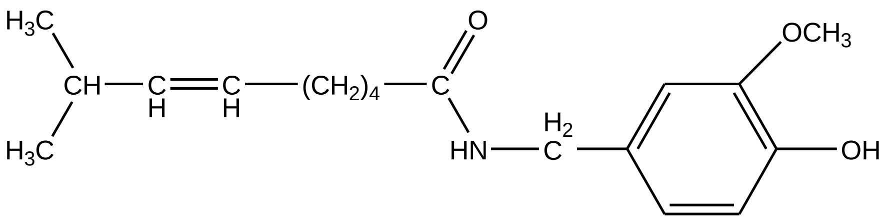
PCP



BZ



F



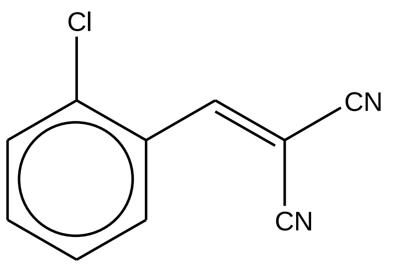
C

Fig 8. Physicochemical Agents

6. Tear Gas Agents-

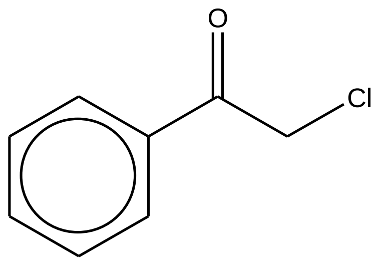
The World Health Organisation defines riot control agents as "chemical agents capable of inducing a temporary disability that lasts a little longer than the exposure period when used in field concentrations". A lacrimating chemicals targeting the eyes are a common option out of the numerous types of tear gas. Lacrimators, or tear gases, by inducing eye pain, lacrimation and blepharospasm, easily kill the victims.Tear gasses are known to be effective as a means of 'non-lethal' crowd control and although permanent injury is uncommon, adverse eye effects are reported [34].With the very harmless term, nerve gas (or "tear gas") are forms of toxic substances that induce extreme eye and respiratory discomfort and inflammation, resulting in serious eye swelling, nausea, and trouble breathing – symptoms that are frequently followed by fear and panics. Although the effects are meant to be transient as well as changeable(which last no longer than thirty minutes), as Crowley states, the threats to well-being are extremely context-dependent. Depending upon conditions and treatment severity, more serious symptoms can include diarrhoea, skin blistering, eye, skin and lung permanent damage, and in rare cases, even death [35]. CN, CS as well as OC known to be efficient lacrimation devices and are poisonous, as calculated by the discomfort level that is stronger for CN, followed by CS and OC. Usually, inflammation is produced in the oculary as well as the respiratory tract within 20–60s of contact. Blepharospasm, photophobia, conjunctivitis along with periorbital oedema are the ocular symptoms. Symptoms can involve a biting or burning pain in the nose, tight mouth, pharyngitides, nausea, dyspnoea, and trouble breathing after inhalation. Originally, CN even identified as Mace, was the most commonly adapted law enforcement agency agent; however, CS has increasingly displaced CN in more recent years. Items comprising CN together with CS is only available for personal self-defence and defence as a handheld spray. OC pepper spray has been highly popular with law enforcement authorities in the past few years, having substituted CN as well as CS towards civilian use [36]. O-chlorobenzylidene malononitrile (CS), oleoresin capsicum (OC, pepper spray), dibenz [b, f]-1,4-oxazepine (CR), and 1-chloroacetophenone (CN) are some main RCAs adapted after World War II. CN was the most widely used RCA until the 1950s, but in response to frustration with the compound's potency and durability a CN alternate quest has been launched. The American researchers invented CS in 1928 for use as an RCA. This chemical, which at the time was considered more potent but less toxic than CN, has been adapted standard RCA by US. In 1959, reserve. CS was the most popular RCA in the following decades, and it is still commonly used. Teargas agents CS, CN and CR are electrophilic agents [37]. The structures of these agents are given below in the (figure. 9)

CS



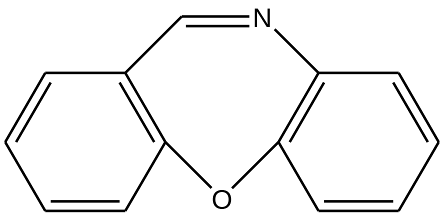
2-Chlorobenzalmalononitrile

CN



2-Chloroacetophenone

CR



Dibenz[b;f][1, 4]oxazepine

Fig 9. Chemical Structures Of Commonly Used Tear Gas Agents

Effects of Chemical Warfare-

As we know that chemical warfare has many destructive and dangerous effects on both living organisms as well as environment also.

Effects on Humans-

- As it binds and enzyme activates acetylcholinesterase (AChE), the nerve agents in organophosphorus (OP) are known as highly poisonous compounds.
- [AChE Suppression leads to excessive deposition of acetylcholine which results incholiergic tissue as well as organ relaxation. It may create a human cholinergic disaster that endangers existence .It inhibits AChE through the creation of a covalent bond amongst phosphorus atom in the nerve agent and the residue of serines in the enzyme. The activity leads to fluorine being substituted otherwise destroyed in GB, GD, and GF. Both GA and VX binding vary because cyanide or thiol leaves the group respectively. Spontaneous enzyme reoccurrence or water-related hydrolysis reactions results in associated alkyl methylphosphonic acids (AMPA). Additionally, removal of the O-alkyl group when the enzyme is attached produces a highly strengthened organophosphoryl-ChE connection, which is called aging. Since ageing, the enzyme is immune to reactivation by oxides applied in the direction of post-exposure treatment as well as other nucleophilic reactives. The agents' spontaneous reactivation and aging rates differ according to O-alkyl level. For example, for the first 48 h of reduced aging, VX-hinders red blood cell (RBC) AChE reactivates at an average rate about an 0.5–1 percent per hour. Conversely, GD-hinders AChE does not reactivate

simultaneously as well as a rapid ageing rate having half-life period of about two minutes [38, 52].

- Five drums were **digged** from an abandoned car building site parking in Qiqihar District, Heilongjiang Province, China, on August 4, 2003. The drums were filled with Sulfur mustard (SM) and Lewisite blended liquid vesicents secretly developed by the late Japanese Imperial Army during World War II.The 5 barrels have been sent to the scrap iron warehouse, where the individual who ripped off the drums died 17 days but after crash and then transferred to the power plant. The condition deteriorated as the polluted soil was removed from the site plan to the numerous sites containing the school field and private homes. There were 44 confirmed casualties, out of which 26 found to be in proximity of drums as well as the CWAs. Other 18 patients have been partially killed via direct contact withpolluted soil. Nearly all patients showed 'chest pain,' 'palpitation,' 'weakness,' 'loss of ability to focus,' and 'incapacity to Decipher /remember' at the first medical checkup in March 2006. There were also comments that 'I forgot easily what I was memorizing.' The women 'eyes had become dilated, and this has stabilized by 2008. A disorder was originally theorized of group insanity and PTSD. The screening room is inside and dry, outdoor temperatures however remain below zero. Community paranoia and PTSD are inadequate treatments to describe the reported signs of abnormally intense vomiting, and regular urination occurring about every ten minutes in severe cases. Furthermore, the reported health conditions such as 'painful throat,' 'lack of energy,' 'incapacity to focus' neither indicative of long term bronchitis that shows symptoms such as of cough as well as mucus, nor do it suits any dermatologic condition. The quality of life of the patients is believed to have been decreased mostlysince cerebral cortex and insects harm. This claims may explain signs such as memory loss and the appearance of dilated pupils in almost every patient[39].
- The thoracic surgery department belongs to Imam Reza Hospital, Tabriz University of Medical Sciences, Tabriz, Iran, had been referred to at 43 y / o male in the autumn of 2011. Owing to his long-term obstructive airborne symptoms as well as dyspnoea exercised by chemical weapons at the 1986 Iran-Iraq war (Sulfur mustard),he was treated chronically with bronchodilators.He obtained several brief studies of systemic as well as oral anti-bacterial drugs accompanied by corticosteroids as well as bronchodilators, mainly salbutamol or ipratropium hydrobromide sprays, following his initial 6 months' diagnosis related to dermatology and respiratory symptoms of the wounds.He was also subjected to multiple bronchoscopies which showed diffuse inflammatory changes in the broad airways without any significant stenosis. His skin condition involved dryness of the scalp, hyperpigmentation, and mild symptoms of contact dermatitis that cured only local emollients regularly. His respiratory symptoms have been aggravated occasionally over this time owing to bacterial as well as viral infections, particularly in falls and winters, however the symptoms of illness have remained constant during the past 10 years without the need for hospital admission [40].

Effects On Environment (Deep Sea Ecosystem)-

There is a really clear desire to examine the activities of a CWA at submarine discarded military munitions(DMM) spots identifying the probable serious threat to human health, atmosphere and the eco-system of the deep sea. This is estimated that between 1919 and 1970 in the coastal waters of the United States 29,000 metric tons of chemical warfare agent (CWA) found inside military weapons were discarded [41].

The Baltic Sea occupies an area of 415,000 km, with an average depth of 52 m and is fairly shallow. The formation took place after the last glaciation and the current salinity level settled 2,000 years ago, world's biggest brackish ecosystems. Baltic salinity levels range from 1 to 20 PSU, averaging 7 PSU. These young environment offers numerous ecological resources to a wide community of people living with in catchments, although being highly susceptible to certain forms of health impacts.During the end of the second world war, the Baltic Sea continued being used as a dumping ground for at least 40 000 tonnes. The poisonous loads accounted for as many as 15,000 tonnes, 80% of which was mustard gas. The Gotland Deep was detonated in May and September 1947 with the discarding of approximately 2000 tons of CW of 1,000 tons of CWA. Studies carried out in the CHEMSEA project, on the other hand, proved the presence of an illegal disposal spot in the Gdańsk Deep. Although the volumes of aquatic discarded CWA are considered to cause significant challenge to a Baltic Sea environment, which already have a significant nutrient-related environmental depletion that contributed to a decline in dissolved oxygen concentrations (DO).In the lower waters and beneath the halocline formation of the "benthic deserts."Water pollution has negative effects on aquatic environments, especially in reservoirs, as hypoxia and anoxia not only affect organisms but also their habitats [42].

The interaction between the human and CWA via dumpsites occurs directly by unintended working contamination, usually through predator that captures CWA ammunition using trawl or net as well as indirectly by polluted seafood. After World War 2, Germany became demilitarized and the Allied powers removed up to 200,000 tons of CWA weapons from the German inventory with in sea. Huge volumes have also been discharged from Japanese reservoirs into Asian waters and the United States' east and west coasts, as well as the Caribbean and Pacific Seas and several other areas around the globe. The 1972 London Convention for the Control of Maritime Pollution through Waste Dumping and Other Matters (MARPOL) prohibited disposal at sea [43].

CONCLUSION-

Within this article, we expanded briefly on the various forms of CWAs which are used as chemical weapons within chemical warfare. Chemical warfare left humanity and the environment with many deadly and long-term negative effects. Such CWAs are prohibited with the help of several treaties. But the misuse of these CWAs is still a big danger to the world.

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