THE DEVELOPMENT OF EMERGENCY LIFE RAFT WITH INTEGRATED WATER DISTILLER SYSTEM (ELRIDS)

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PEMBANGUNAN RAKIT KESELAMATAN DENGAN FUNGSI INTEGRASI SISTEM PENYULING AIR *(ELRIDS)*

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Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Reka Bentuk & Inovasi)

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ABSTRACT

During survival situation in the middle of the ocean, a survivor must protect himself from threatening elements such as blistering sun, hypothermia, dehydration, and sharks. A life raft seems to be the most perfect device to shelter them from those elements. Currently however, there is none of the life raft available in the market had an integrated feature that enable survivors to purify seawater in to safe drinking water, except rain collector. The second most valuable source of life (the first is oxygen) usually unavailable or has limited recourse on a life raft. It is obviously strange to think that manufacturer of life raft had more of their concern on the lower priority parts of survival such as first aid kit and getting spotted. This dearth space of the feature, which had became the inspiration to come out with the idea of 'Emergency Life Raft With Integrated Water Distiller System' (ELRIDS). This paper explains in detail about the development of the ELRIDS after in-depth of some intellectual research.

ABSTRAK

Dalam situasi kecemasan di tengah lautan, seseorang haruslah melindungi dirinya daripada unsur-unsur yang menjejaskan peluangnya untuk selamat. Contohnya seperti panas terik matahari, hipotermia, penyahhidratan dan bahaya jerung. Satu rakit keselamatan kelihatan seperti alat yang paling sempurna untuk melindunginya daripada elemen-elemen tersebut. Namun, pada masa ini di sana tiada satupun rakit keselamatan yang terdapat di pasaran mempunyai satu ciri yang bersepadu yang membolehkan orang yang terselamat menulenkan air laut kepada air yang selamat untuk diminum, apa yang ada hanyalah setakat pengumpul hujan. Sumber kehidupan yang kedua paling berharga (pertama adalah oksigen) biasanya tidak disediakan atau mempunyai sumber yang terhad di atas sesebuah rakit keselamatan. Adalah ironic apabila memikirkan bahawa para pengeluar rakit keselamatan lebih menumpukan pada keutamaan hidup yang lebih rendah; seperti peti pertolongan cemas dan ciri-ciri untuk mudah dikesan. Kekurangan pada rekabentuk rakit keselamatan inilah yang telah mencetuskan ilham untuk muncul dengan idea 'Rakit Keselamatan Dengan Fungsi Integrasi Sistem Penyuling Air' *(ELRIDS)*. Laporan ini membincangkan perincian tentang pembangunan *ELRIDS* setelah beberapa kajian ilmiah dilakukan secara terperinci.

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CHAPTER 1

INTRODUCTION

Near-coast activity such as kayaking expedition, the risk to obtain lost at sea is minimal. It is rare when we paddling father than 20 nautical miles from shore. Sometimes storm could attack followed by strong winds. But, that is not something the kayakers must usually worry for. On the one hand, the sailors who navigate on larger ships (ocean cruiser, fishing vessels, or rarely aircraft) could be in this situation one day. It is interesting to look at the experience of many shipwrecked survivors and adventurers and to learn from their errors and discoveries. In a castaway situation, the drowning is the common cause of the death followed by hypothermia. People who survive the first few will have to follow the same rules as for the ground survival. The priority should be given to protect them from elements of threats (sun, coldness, shark), then finding water, and then for a longer period finding for food. Carrying signaling devices could also significantly increase the chance to be saved.

1.1 Problem Statement

The topic that grabbed most of attention is on the ocean. It is surprising that the largest mass of water on the Earth is not safe to drink. Seawater is about 3 times as salty as human blood; [4] normally the fluid in body cells is about the same saltiness as the blood. But if we drink seawater, osmosis process would occur where the less salty water in the cells will flow out through the cell walls into the saltier blood. This causes the cells to be 'pickled' as it shrink and malfunction, resulting in weak aching muscles and an irregular heart beat a loss of concentration and mental function. The bloods high concentration of salt causes the kidneys to get rid of the excess by producing more urine. Drinking seawater not only fails to provide fluid the body can use, but also causes the body to lose precious fluid within the body [2].

Though there are some isolated cases of ocean sailors surviving at sea by drinking seawater. French man, Dr. Alain Bombard (1952), revealed his findings. Dr Bombard said that he drifted for 63 days on a raft 'without any food and water other than that which the ocean provided' and on the basis of this he recommends not drinking more than about a liter a day of seawater, as he says he got sick if he drank more than this. But Bombard was not just drinking seawater he was eating fish and drinking rainwater (which the ocean provided), and the fluids in most fish are fine to drink.

Inflatable rafts have proved to be much more efficient in survival situations than dinghies. When it's not inflated, it can be stored in small container, which spares a lot of area, and there can be more stand-by containers placed on the deck. These raft also easier to deploy from a ship or cruiser during emergency, as it does not require davit mechanism that is necessary for dinghies deployment. It will provide dry shelter and isolates us from the coldness of the seawater. The well-prepared sailors will have all they need to survive in their raft and signal their position.

The only drawback of a modern life raft is it could not provide us with water, which is so precious during critical survival situation. Many of these raft equipped with rain collector, but it only be useful when raining. There is also limitation of how much rain we could collect, depends on the size of water reservoir. Some high-end life raft such as owned by US Navy had additional survival equipment, including a 35-gallon per day manual reverse osmosis desalinator (MROD) to purify seawater. The drawback, MROD is usually expensive and it requires electric power to operate. Power from battery or gasoline generator would not last long and solar panel will increase the cost and it is vulnerable. There is also limitation on how much the osmosis membrane can filter out salt from seawater. Although some type of the membrane is reusable by reverse flushing, but only works for a few times.

1.2 Objective

The objective for this project is to design and to produce a working prototype that makes improvement from conventional inflatable life raft. The major new feature of this raft is it integrated with mechanism the enable production of purified water from seawater, and produces its own power. This radical improvement must be achieved by using simple and foolproof mechanism; and with the use of electric power which something that most likely will be find nowhere in the middle of the ocean. The life raft also must surpass the requirement of International Sailing Federation (ISAF).

1.3 Scopes

a. To do market research for similar products.
b. To do research about water purification processes.
c. To design and making a working prototype of ELRIDS seawater distiller unit.
d. To produce detailed drawing of ELRIDS.
e. To make ELRIDS mock-up model.
f. To make research of generating electrical power from sea.

CHAPTER II

LITERATURE REVIEW

2.1 Brief Information About Water

Water is a common chemical substance that is essential to all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state, ice, and a gaseous state, water vapor. From a biological standpoint, water has many distinct properties that are critical for the proliferation of life that set it apart from other substances. Water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the body [2].

Water is thus essential and central to these metabolic processes. Therefore, without water, these metabolic processes would cease to exist. Water is also central to photosynthesis and respiration. Photosynthetic cells use the sun's energy to split off water's hydrogen from oxygen. Hydrogen is combined with CO_2 (absorbed from air or water) to form glucose and release oxygen. All living cells use such fuels and oxidize the hydrogen and carbon to capture the sun's energy and reform water and CO_2 in the process (cellular respiration) [2].

Water is also central to acid-base neutrality and enzyme function. In acid, a hydrogen ion (H+, that is, a proton) donor, can be neutralized by a base, a proton acceptor such as hydroxide ion (OH−) to form water. Water is considered to be neutral, with a pH (the negative log of the hydrogen ion concentration) of 7. Acids have pH values less than 7 while bases have values greater than 7. Stomach acid (hydrochloric acid) is useful to digestion. However, its corrosive effect on the esophagus during reflux can temporarily be neutralized by ingestion of a base such as aluminum hydroxide to produce the neutral molecules water and the salt aluminum chloride. Human biochemistry that involves enzymes usually performs optimally around a biologically neutral pH of 7.4 [5].

2.2 The Importance Of Water To Human Body

Up to 60 percent of the human body is water, the brain is composed of 70 percent water, and the lungs are nearly 90 percent water. About 83 percent of our blood is water, which helps digest our food, transport waste, and control body temperature. Each day humans must replace 2.4 liters of water, some through drinking and the rest taken by the body from the foods eaten. The cells in our bodies are full of water. The excellent ability of water to dissolve so many substances allows our cells to use valuable nutrients, minerals, and chemicals in biological processes [3].

Water is vital to many functions in the body. These include maintaining cell structure, forming a solvent within which chemical reactions in the body can take place, physically transporting other nutrients and oxygen through the body via the bloodstream, transporting white blood cells to fight infection via the lymphatic system, and enabling the body to get rid of waste products via the excretory systems, such as through the formation of urine [3].

2.3 Brief Information About Dehydration

Dehydration is a removal process of water from an object. Medically, it is a condition in which the body contains an insufficient volume of water for normal functioning. The best treatment for minor dehydration is drinking water and stopping fluid loss. Water is preferable to sport drinks and other commercially sold rehydration fluids, as the balance of electrolytes they provide may not match the replacement requirements of the individual. To stop fluid loss from vomiting and diarrhea, avoid solid foods and drink only clear liquids.

In more severe cases, correction of a dehydrated state is accomplished by the replenishment of necessary water and electrolytes (rehydration, through oral rehydration therapy or intravenous therapy). Even in the case of serious lack of fresh water (e.g., at sea or in a desert), drinking seawater or urine does not help, nor does the consumption of alcohol. It is often thought that the sudden influx of salt into the body from seawater will cause the cells to dehydrate and the kidneys to overload and shut down but it has been calculated that an average adult can drink up to 0.2 liters of seawater per day before the kidneys start to fail [4].

When dehydrated, unnecessary sweating should be avoided as it wastes water. If there is only dry food, it is better not to eat, as water is necessary for digestion. For severe cases of dehydration where fainting, unconsciousness, or other severely inhibiting symptom is present (the patient is incapable of standing or thinking clearly), emergency attention is required. Fluids containing a proper balance of replacement electrolytes are given orally or intravenously with continuing assessment of electrolyte status; complete resolution is the norm in all but the most extreme cases.

A normal person's daily supplement for water depends on the activities he/she does. It is also highly dependants to the environment temperature. Our muscular system generates heat while working out. Thus, the harder our muscles work and the hotter the environment, the more we sweat. Basically, the amounts of our requirement for water consumption are the same volume of water we loss due to dehydration. In humans, dehydration can be caused by a wide range of diseases and states that impair water homeostasis in the body. However this case study, it just includes the external or stress-related causes such as:

a. Prolonged physical activity without consuming adequate water, especially in a hot and/or humid environment
b. Prolonged exposure to dry air, e.g., in high-flying airplanes

c. Survival situations, especially desert survival conditions
d. Diarrhea - A condition in which the sufferer has frequent watery, loose bowel movements
e. Hyperthermia - An acute condition which occurs when the body produces or absorbs more heat than it can dissipate (heat stroke)
f. Hypovolemic - Serious medical condition where the tissue perfusion is insufficient to meet demand for oxygen and nutrients (shock)
g. Lacrimation – Process of cleaning and lubricating the eyes (tears)
h. Blood loss or hypotension due to physical trauma
i. Vomiting
j. Burns

Water is lost from the body as urine, in faeces and by evaporation from the skin and lungs (the latter two make up what is called 'insensible water losses'). More water is lost from the skin and lungs in high temperatures, at high altitude and when the air is dry. Even in the absence of visible perspiration, approximately half of water loss occurs through the lungs and skin [4]. Water loss through the skin is usually about 800-1000ml per day.

In a hot climate, water loss of 500ml per hour is not unusual, but sweating rates can be as high as 2500ml per hour. Expired air is saturated with water vapor and the average water loss from this source is about 300ml per day - this figure may increase if the air is very dry, or during hyperventilation. Urine output can range from 1-2 liters per day, but can be more when large volumes of fluid are consumed. Varying urine output is the main method by which the body regulates net water balance in response to a wide range of fluid intakes and losses.

2.4 Daily Water Requirement

The normal daily turnover of total body water is approximately 5-10 per cent in adults.[1] The amount of water required by the body can vary markedly, depending, for example on dietary factors, physical activity level, environmental conditions, metabolism and health status. The kidneys also require a minimum amount of water to excrete soluble waste products. Studies indicate that daily water turnover is 3.3 liters for sedentary men and 4.5 liters for active men. For more active adults, particularly those living in a warm environment, daily water need can increase to about 6 liters. It is therefore difficult to estimate a general water requirement, because of the wide variability within and between individuals [3].

A review into the origins of advice regarding daily water requirements found that a recommendation from the US National Research Council may have been the source of advice to 'drink at least eight glasses of water a day'. (1 glass/cup - approx. 8 ounces = 240ml; therefore 8 glasses = approx. 1920ml). The National Research Council updated its advice in 1989, recommending that for practical purposes the water requirement for adults could be estimated as '1ml per kcal energy expenditure for adults living under average conditions of energy expenditure and environmental exposure'.

Thus a person eating 2900kcal would require 2900ml of water. However, the Council did not comment on the source of the water required. This may have perpetuated the misconception that all of this water requirement must be in the form of drink. Whereas, in accordance with the table below, if an adult gains in the region of 1 liter of their 2500ml water requirement from food, and metabolic water contributes a further 250ml, this leaves only 1250ml to be consumed in the form of drink.

Table 2.4: Example of water balance in the body [5]

Source	Water intake (ml/day)	Source	Water loss (ml/day)
Food	1120	Urine	1300
Drink	1450	Lungs	300
Oxidation of nutrients (metabolic water)	280	Skin	920
		Feces	60
Total	2580	Total	2580

2.5 Water Purification by Desalination

Desalination, desalinization, or desalinization refer to any of several processes that remove excess salt and other minerals from water. Desalination typically requires large amounts of energy as well as specialized, expensive infrastructure, making it very costly compared to the use of fresh water from rivers or wells (bores). As of July 2004, the two leading methods were reverse osmosis (47.2% of installed capacity world-wide) and multi-stage flash (36.5%).

Osmosis is the net movement of water across a partially permeable membrane from a region of high solvent potential to an area of low solvent potential, up a solute concentration gradient. It is a physical process in which a solvent moves, without input of energy, across a semi permeable membrane (permeable to the solvent, but not the solute) separating two solutions of different concentrations. Below is a model of an osmotic system:

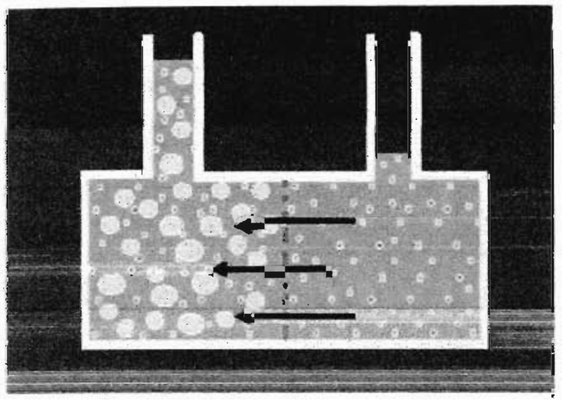

Figure 2.5.1: Model of an osmotic system

A semi-permeable membrane separates two compartments. The size of the pores is large enough to let small particles (ions, molecules) pass freely though small enough to inhibit the passage of larger molecules. In the left compartment develops a higher osmotic pressure due to the hydration sheath that surrounds each particle. Since it contains more 'water-binding' particles, expands the volume of the left compartment.

Reverse osmosis is a separation process that uses pressure to force a solvent through a membrane that retains the solute on one side and allows the pure solvent to pass to the other side. More formally, it is the process of forcing a solvent from a region of high solute concentration through a membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure. This is the reverse of the normal osmosis process, which is the natural movement of solvent from an area of low solute concentration, through a membrane, to an area of high solute concentration when no external pressure is applied. The membrane here is semi-permeable, meaning it allows the passage of solvent but not of solute.

The membranes used for reverse osmosis have a dense barrier layer in the polymer matrix where most separation occurs. In most cases the membrane is designed to allow only water to pass through this dense layer while preventing the passage of solutes (such as salt ions). This process requires that a high pressure be exerted on the high concentration side of the membrane, usually 2–17 bar (30–250 psi) for fresh and brackish water, and 40–70 bar (600–1000 psi) for seawater, which has around 24 bar (350 psi) natural osmotic pressure which must be overcome.