

## Study on High Natural Radiation Impacts to Peripheral Blood Cells in Population Living in Botteng Village, Mamuju, West Sulawesi

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**Abstract.** *This study describes the long-term effects of low dose radiation to the hematopoietic parameters in the blood of population living in Mamuju of West Sulawesi, an area which has high natural radiation. Peripheral bloods were obtained from community members of Botteng village, covering 70 people that consist of 35 women and 35 men as study group. For control group the bloods were taken from areas with normal levels of exposure in the Keang village covering 23 populations that consist of 13 women and 10 men. Age of both groups were ranging between 14-70 years. The blood components were measured by using the hematopoietic analyzer, the ABX Micros 60, located in Clinical Laboratory of PTKMR-BATAN according to standard procedure. The results showed that the levels of haemoglobin (Hb), erythrocytes, leukocytes, absolute lymphocytes, platelets, MCV, RDW, PDW, MPV, monocytes and granulocytes were not decreased significantly due to radiation and were within normal limits and there is no significant difference between these two groups ( $p > 0.05$ ). Other components (HCT, MCH, MCHC, and MPV) showed normal data distribution and significantly different with that of control ( $p < 0.05$ ) that may related to daily life style such as smoking and coffee consumption. It can be concluded that there is no impact of exposure to high natural radiation in Mamuju, West Sulawesi to hematopoietic system.*

*Keywords: haematology, low doses, natural radiation, Mamuju*

### Introduction

Blood is an important part of the body's circulatory system. Blood consists of two parts, namely the liquid (blood plasma) and blood cells. Blood cells include erythrocytes, leukocytes, and platelets. Leukocyte function as immunologic system of the body. Erythrocytes joint function in tissue oxygenation hemoglobin and platelets play a role in blood clotting system. These blood cells are produced in the bone marrow. Radiosensitivity of types of blood cells varies. Peripheral blood lymphocytes are the cells that most sensitive to radiation so it susceptible to damage DNA. Therefore peripheral blood lymphocytes are the cells that most commonly used as biodosimetry. Biodosimetry is the prediction of the dose of ionizing radiation received by a person based on biological material changes in the body. The most resistant cells are erythrocytes (Ethel, 2003). Whole body radiation dose of 0.5 Gy can cause a decrease in the formation of blood cells so that the blood cell count decreases. A decrease in blood cell count will be seriously affected if not treated immediately because the blood has an important role on the human body functions such as immunity, oxygenation, hemostasis and other characters (Flidner, 2012).

The bone marrow system is very radiosensitive and therefore the analysis of hematopoietic index for people affected by radiation is necessary and the blood-forming cells in the bone marrow are particularly vulnerable to radiation (Hendee, 1990). In Nigeria, it has been estimated that approximately 160 people per year are at risk of cancer due to radiation

exposure of terrestrial gamma (Little, 1995; Liu, 1987; Loken, 1993). The main component of radiation exposure in daily life for the general public is the natural radiation that could have come from outer space as cosmic radiation and occurs in soil, air, water or building materials (terrestrial radiation) (Ethel, 2003; Hendee, 1990).

Natural radiation is the main source contributing to the collective dose received by the population of the world both from external and internal sources of exposure to natural radiation in soil and produce a critical component of background radiation exposure of the population in the world. Some radionuclides were detected in the soil and the natural environment as well radioactivity associated external exposure due to gamma radiation that depends on the geological and geographical conditions and emerge at different levels in the soil of each region in the world (Luckey, 1994; Nordenberg, 1990). Terrestrial radiation begins by radioactive chemicals that present when the earth was formed. They are found in igneous, metamorphic, and sedimentary rocks in various regions in the world (Seed, 1993; Shapiro, 1990). In Kerala (India) and some parts of France and Brazil, the dose was recorded up to 20 times the global average. In some other countries (e.g. Finland) the average dose was several times higher, and in particular, many citizens receive an effective dose exceeding the allowable dose (of 20 mSv/year) (MacMahon, 1989; Mossman, 1998).

The area with the level of natural radiation exposure reaches 20 mSv or more, categorized as High Natural Background Radiation (HNBR). Studies conducted by Syaeful et al. (2014) and Iskandar et al.

(2010) showed that Mamuju district has an highest dose rate compared to other parts of Sulawesi and even Indonesia, which reached 2.800 nSv/hour. In the highest gamma dose rate in Botteng village there is a location with a level of gamma radiation dose of 10,000 nSv/hour (national average of 50 nSv/hour). Another study conducted by Alatas et al. on the cytogenetic responses that were evaluated in Mamuju population and showed no significant difference in the frequency of chromosomal aberrations in lymphocytes of people who live in that areas compared with living in normal areas (Alatas, 2012).

Ionizing radiation affects the organism through the water radiolysis. DNA damage occurs as a result of interaction with reactive oxygen species. Cell death or mutations that may result from DNA damage. But the damage to cells depending on the type of radiation, dose rate and dose (Sawant, 2009; Baskar, 2012). Exposure to ionizing radiation is sensitive to the bone marrow, gastrointestinal tract, and skin tissue including the central nervous system (CNS), lungs, heart, liver, kidneys, and reproductive organs can be affected (Miller, 2013; Rea, 2010). Eyepiece is also considered one of the most radiosensitive tissues in the human body and could have resulted in cataractogenesis (Ainsbury, 2009; Schmid, 2007; Barcellof-Hoff, 2012). In hematopoietic syndrome lymphocyte cells are very sensitive to radiation and radiation can decrease the amount within 1 to 3 hours after exposure which may also cause drop in the number of leukocytes, platelets, and erythrocytes. Shortage of white blood cells can trigger infections and shortage of platelets can cause uncontrolled bleeding in body tissues. Red blood cells are less sensitive to radiation, but its decrease would result in highrisk of health problems and may lead to stochastic and deterministic effects (Shimizu, 2010; Akleyev, 2010).

This study aimed to determine the alteration in hematology (hematopoietic components) in blood of resident in Botteng Village, Mamuju due to high natural radiation exposure. These peripheral blood lymphocytes are the cells most widely used in the study using the man as an object of research. Very low radiation exposure can cause hormesis effect, stimulating the hematopoietic function as an expression in the immune system and hematopoietic function increases with increasing exposure to radiation(UNSCEAR, 2010).

## **Materials and Methods**

### ***Blood Sampling***

Samples were obtained from the local indigenous healthy people, and they did not receive any medical action with radiation and with age range between 14-

70 years. For areas with high exposure to natural radiation (HBRA) samples were taken from the people living in village of Botteng (sub villages of Tekbong, Kurasalimbo, Tangnga, Kassa, and Taludu) that covering 70 people consisting of 35 women and 35 men. Control samples were obtained from the area with a normal level of natural radiation exposure (NHBRA) of Keang Village (Lomali and Tabelaalang sub villages) on 23 population consisted of 13 women and 10 men. Prior to blood sampling, the population is given an explanation about the purpose of this study. Residents are willing to become respondents were asked to sign an informed consent form (willingness to give blood samples). About 2 mL of peripheral blood were drawn using a syringe equipped with a vacutainer containing EDTA anticoagulant. The blood sample was immediately taken to the Cytogenetic Laboratory in PTKMR BATAN in Jakarta.

### ***Hematologic Examinations***

Blood in a tube that has been mixed well was examined by using a hematology analyzer ABX Micros 60 according to standard protocol. These parameters are hemoglobin level, the number of erythrocytes, platelets, leukocytes, lymphocytes, granulocytes, monocytes, hematocrit (HCT), mean cell/corpuscular volume (MCV) or corpuscular volume average (VER), mean Cell hemoglobin Content (MCH) or corpuscular hemoglobin average (HER), mean Cellular hemoglobin concentration (MCHC) or hemoglobin concentration erythrocyte average (Kher), Red Blood Cell Distribution Width (RDW), Platelet Distribution Width (PDW), Mean platelet volume (MPV).

### ***Research Ethics***

Ethic of the study was obtained from the Ethics Committee for Health Research, National Agency for Health Research and Development, Ministry of Health of the Republic of Indonesia No. LB.02.01/5.2.KE.051/ 2015, date of January 29, 2015.

## **Results and Discussion**

This paper presented the results on the high natural radiation effects on haemopoietic system in residents of Botteng, Mamuju, West Sulawesi, as an area with relatively high natural background radiation levels (HBRA) in Indonesia. The average level of exposure to gamma radiation in this district is 631.4 nSv/h (Sawant, 2009), while the average level of total external radiation dose rate in Indonesia is 67.5 nSv/h (Nel, 2002).

Table 1 shows the results of hematology of the blood of people in HBRA compared with controls taken from areas with levels of exposure to NBRA. It can be seen that the levels Hb, erythrocytes, leukocytes, lymphocytes absolute, platelets, MCH, RDW, PDW, monocytes and granulocytes did not significantly decline and is still within normal limits. The results of statistical tests showed that that levels of blood components in the HBRA group showed no significant difference when compared with that of NBRA as controls ( $p > 0.05$ ). For other components (HCT, MCV, MCHC) the statistical test results showed a significant differences when compared with that of the control ( $p < 0.05$ ).

Bone marrow cells included in the cells that are actively proliferate and are susceptible to damage from exposure to ionizing radiation. It is known that a low level of radiation, i.e. 0.25 Gy, can cause changes in the blood constituent, particularly the cessation of the formation of blood cells (hematopoiesis) with result in

the changes both by direct damage to tissue hematopoietic and the influence to neurohormonal mechanisms. Leukocytes, platelets and lymphocytes are blood cells that are most sensitive to radiation, whereas erythrocytes and Hb are cells that are quite resistant to radiation. From the results of measurements of hemoglobin levels in blood of Mamuju population presented in Table 1, it can be seen that the hemoglobin levels did not decrease significantly and still within the normal limit (11 to 16.5 g/dL). These mean values are 14,397 g/dL for HBRA and 14,800 g/dL for control.

Table 1. The average level of each measurement of hematology among residents in areas of high natural radiation (HNBR) and normal levels of exposure to natural radiation (NHBRA).

Hematological parameters	Normal Values	HBRA (n=70)		NBRA/control (n=23)		P(T<=t)
		Mean	STD	Mean	STD	
HB gr/dl	11-16,5	14.3971	1.4880	14.8000	1.5221	0.3000
erythrocytes $10^6/\text{mm}^3$	3.80 - 5.80 $10^6/\text{mm}^3$	5.0530	0.7445	5.1953	0.5798	0.4430
Leukocytes $10^3/\text{mm}^3$	4 - 10 $10^3/\text{mm}^3$	7.8643	1.9479	8.1421	2.4978	0.6058
Platelets $10^3/\text{mm}^3$	150 - 390 $10^3/\text{mm}^3$	258.4143	78.9033	244.9474	76.2441	0.5082
HCT (Hematocrite) %	35 - 50 %	43.8214	4.8824	58.1211	3.568	<b>0.0193</b>
MCV 80-97/( $\text{um}^3$ )	80 - 97 $\text{um}^3$	87.9857	5.0000	89.5789	4.3374	<b>0.0226</b>
MCH ( pg)	26.5 - 35 Pg	28.7857	2.5644	28.6421	1.9594	0.8214
MCHC ( g/dl )	31.5 - 35 g/dl	32.8557	1.5751	32.5316	1.4742	<b>0.0252</b>
RDW (%)	10 - 15 %	12.6786	0.9802	12.2632	0.5449	0.0803
MPV ( $\text{um}^3$ )	6.5 - 11 $\text{um}^3$	7.7500	1.1642	8.2053	0.5212	0.1016
PDW ( L.%)	10 - 18 %	11.7586	1.8879	11.0947	0.9536	0.1430
Lymphocytes $10^3/\text{mm}^3$	1.2 - 3.2 $10^3/\text{mm}^3$	2.7586	0.8841	2.6105	0.7015	0.5023
Monocytes $10^3/\text{mm}^3$	0.3 - 0.9 $10^3/\text{mm}^3$	0.5429	0.2262	0.6105	0.2492	0.2609
Granulocytes $10^3/\text{mm}^3$	1.2 - 6.8 $10^3/\text{mm}^3$	4.6100	1.5174	4.9211	1.9654	0.7759
Lymphocytes %	17 - 48 %	36.2014	8.9571	33.7263	7.9110	0.2772
Monocytes %	4 - 10 %	7.4429	2.3185	8.0368	2.1600	0.3181
Granulocytes %	43 - 76 %	56.2343	9.3695	56.9211	9.0230	0.7759

Note : yellow shading and bold numbers are very low levels.

Erythrocyte production is controlled by a negative feedback mechanism that is sensitive to the supply of oxygen to the body tissues. Increased production of erythrocytes can be caused by several factors, namely bleeding, heart failure, and pulmonary disease (Ethel, 2003). Results in number of blood erythrocyte in population of Mamuju (Table 1) shows that the number of erythrocytes in HBRA did not decrease compared to normal values ( $3.80\text{-}5.80 \times 10^6$  per  $\text{mm}^3$  versus  $5.053\text{-}5.195 \times 10^6$  per  $\text{mm}^3$ ). The relationship between hemoglobin levels and the number of erythrocytes are known to rise and comparable between hemoglobin and erythrocytes (Figure 1). The relationship between the number of erythrocytes with hemoglobin levels following the line with equation of  $Y = 0.958 X + 9.555$ , which means that the higher hemoglobin levels would have the higher number of erythrocytes. Red Cell Distribution Width (RDW) is the coefficient of variation of erythrocytes volume (differences or variations in the size/area of erythrocytes). This value as an estimate that useful RDW high early anemia can indicate the red cells are heterogeneous, and are usually found in iron deficiency anemia case, a deficiency of folic acid and vitamin B12, hemolytic anemia, and sickle cell anemia. The red cells are typically  $6\text{-}8\mu\text{m}$ , the higher variation in cell size indicating the abnormalities, whereas low RDW showing that erythrocyte have small size variations.

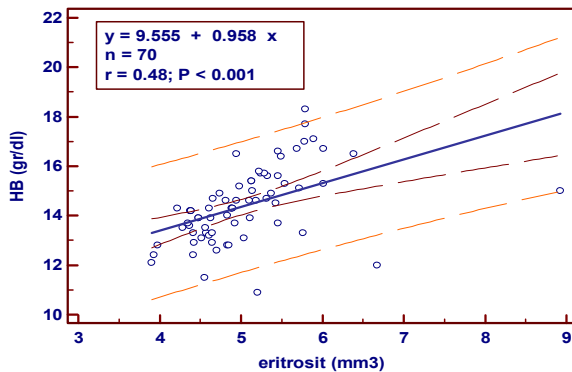


Figure 1. The relationship between hemoglobin concentration with the number of erythrocyte cells/ $\text{mm}^3$

Platelets function in blood clotting mechanism. Thrombocytopenia is a condition in which the number of platelets less than normal that may caused by the initial reaction of drugs, bone marrow malignancy, or bone marrow damages caused by ionizing radiation. The opposite situation is called thrombocytosis, i.e. an increase in the number of platelets due to the bleeding, especially anemia due to chronic blood loss, infection,

postoperative, malignancy and inflammatory diseases and as a result of a decrease in the number of platelets by radiation, the clotting time will increase due to reduced tissue factor which is usually generated by platelet G. The results of measurements of platelet count in Mamuju population are presented in Table 1. It can be seen that the platelets are not significantly decline and is still in the normal range in adults (normal value is  $150\text{-}390103/\text{mm}^3$ ). The average value in HBRA was  $258.4143103/\text{mm}^3$  and control was  $244.9474103/\text{mm}^3$ . Figure 2 shows the relationship between the platelet count with the number of erythrocytes with equation of  $Y=0.000628 X + 4.891$  which means that the more the number of platelets will be the greater the number of erythrocytes. Platelet Distribution Width (PDW) PDW is the coefficient of variation of platelet size. High PDW levels usually found in sickle cell disease and thrombocytosis, while the low PDW levels mean that platelets have small size. MPV is the average volume of platelets. Thrombocytopenia occurred in low MPV, while the high MPV can be used as an indicator of platelet megakaryocytes.

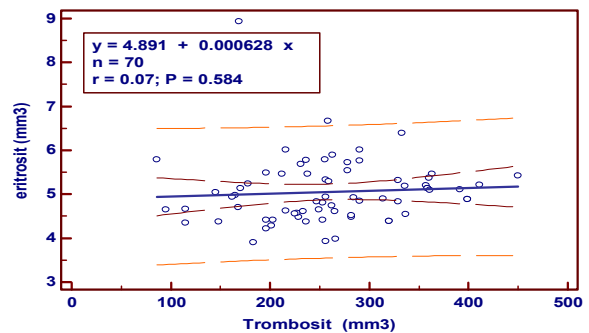


Figure 2. The relationship between the number of erythrocytes/ $\text{mm}^3$  with the number of platelets/ $\text{mm}^3$

According to Campbell et al (2005), WBCs serves to protect the body against invasion of foreign substances such as bacteria and viruses. Infection or tissue damage resulting in an increase in the total number of leukocytes. Increased leukocytes can also be caused by leukemia. Leukemia is a type of cancer that is characterized by proliferation of white blood cells that are not controlled. Results show that the total number of leukocytes in the HBRA group is not significantly different the control group no ( $p > 0.05$ ) as shown in Table 1. However the average leukocyte counts was lower compared to the control group ( $7.86 \times 10^3/\text{mm}^3$  versus  $8.14 \times 10^3/\text{mm}^3$ ). These levels are not affected by environmental radiation and still within normal value ( $4.500\text{-}10.000 \times 10^3/\text{mm}^3$ ).

Statistical analysis on the total number of lymphocytes showed that HBRA group was not significantly different with the control group ( $p > 0.05$ ).

Table 1 showing that the number of blood lymphocyte cells in blood of Mamuju population does not decline (normal value is  $1.2-3.2 \times 10^3/\text{mm}^3$ ). Decrease in number of absolute lymphocyte cells can be used to estimate the severity of a person such as a result of acute radiation exposure. In Figure 3 shows the relationship between the number of leukocytes with the number of lymphocytes by equation of  $Y = 1.167 x + 4.646$  which means the number of lymphocytes increases would have results in the increase of leukocytes number.

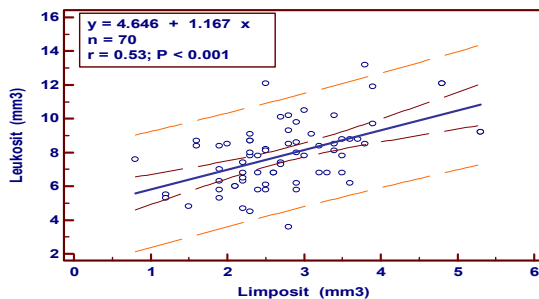


Figure 3. The relationship between the number of leukocytes cells/ $\text{mm}^3$  with the number of lymphocytes cells/ $\text{mm}^3$

Hematocrit is a measurement that determines the number of red blood cells in 100 ml of blood and is expressed in percent (%). The results showed that statistically HCT, MCV and MCHC in the treatment group were different compared to controls ( $p < 0.05$ ) and showing a normal distribution. Mean corpuscular volume (MCV) or average volume of erythrocyte that expressed in femtoliter. MCV is the erythrocyte index that equal to MCH, MCHC. All these can be used to help in diagnose the cause of anemia (a condition in which too few red blood cells). The level of MCV higher than normal means an anemia condition and known as macrocytic (cell size above normal cells). This condition is usually found in people with pernicious anemia, alcoholics, folic acid deficiency, and HIV. MCV below normal means microcytic (cell size below normal cells) and usually found in people with iron deficiency (anemia), thalassemia, and lead poisoning.

Hemoglobin is a protein binder and a carrier of oxygen. Each erythrocyte contains about 300 million hemoglobin molecules (Tavakoli, 2012). Low levels of hemoglobin in the blood is known as anemia. There are many causes of anemia, among the most frequent are bleeding, malnutrition, bone marrow disorders, chemotherapy and systemic diseases (cancer, lupus, etc.). Whereas high level of hemoglobin can be found in people who living in the highlands and smokers. Some diseases such as pneumonia, tumors, preklampsi, hemo concentration. Based on observations and

questionnaires that nearly all male population in Mamuju district are smokers. Some studies found that smokers lymphocytes and DNA damage. However there are some differences about the effects of smoking on DNA damage since many studies have found no significant difference between smoking and non-smoking (Shahid, 2015). Another factor contributing to the higher DNA damage in men is caffeine. Especially in Indonesia people with smoking habits consuming lots of coffee and DNA damage can be caused by a high intake of caffeine (Schmid, 2007).

## Conclusion

Results of the examination showed that exposure to high natural radiation in Mamuju did not influencing the hematopoietic system (hematologic, erythrocytes, leukocytes, lymphocytes absolute, platelets, MCH, RDW, PDW, monocytes and granulocytes) in population Mamuju, West Sulawesi and did not significantly decline and are still within normal limits. The results of statistical tests showed the treatment group when compared with controls showed no significant difference because ( $p > 0.05$ ). For inspection HCT, MCV, MCHC, when compared with the control of the statistical test results showed no significant differences ( $p < 0.05$ ). Villagers in Botteng, Tekbong, Tangnga, Kassa, and Taludu experience anemia and immune deficiency that may because of smoking habits, consumption of food and consuming excess caffeine.

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## Discussion

Q : Setiawan Soetopo

Why do you only assess small number of Mamuju Inhabitant and why do you not mentioned the inclusion and exclusion criteria in your presentation.

A : Teja Kisnanto

In 2015 were the first year of the long term study in BATAN, then only small number of Mamuju inhabitant can be assess in our study. Yes we realized there were a lack information about the inclusion and exclusion criteria in our presentation.