SIMPLE CALCULATION OF THE RADIATION FLUX DISTRIBUTION FOR *BRACHYTHERAPY* USING *MICROSOFT EXCEL*

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Abstract: One of the therapies used to destroy cancer cells is *brachytherapy*. This type of therapy has a radioactive source located in right position or near the cancer cells. In fact, *brachytherapy* is always faced a high risk for patients' safety. Calculation of radiation dose distribution is one tool to optimized therapy. However, mostly people do not understand about it, even medician. This is the background from author to do simple study about calculation of the radiation particle flux distribution and make simple concept about it. The method in this study used coordinate transform to have formula. This calculation based on the geometry of various radioactive sources, being brought closer to the point and line. The formula used to have contour curves with simple computing in *Excel*. Contour curves from this radiation particle flux distribution is in two – dimensional form. The result showed that *isodose* contours curves from research used *excel* were similar with references in quantitatively. This way is very simple and people can easily understand the basic concept of calculate from radiation particle flux distribution.

***Keywords**: Brachytherapy*, Flux, Radioactive Source Geometry, *Isodose*, *Microsoft Excel*

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I. INTRODUCTION

In 2008, cancer causes 7,6 million deaths in worldwide. This number increased by 13 percent of total global deaths. *World Health Organization* (*WHO*) predicts that cancer deaths will continue to rise, and is expected to lead to 13,1 million people died of cancer in 2030 [1]. So, It's common if today people are looking for effective therapies to treat this deadly disease.

One of the therapies used to treat cancer is radiotherapy. Radiotherapy is a treatment method using a beam of high – energy from radiation to kill the tumor/cancer cells. Radiotherapy increasingly chosen by the public, as it is considered to have advantages. The advantages of radiotherapy can be seen on one type of radiotherapy, such as *brachytherapy*. In *brachytherapy*, radioactive packed in seed millimeter sized that inserted into the body. Radiation emitted from the seed just being around the area of tumor/cancer cells. Thus, it will reduce damage to normal cells in the body.

When *brachytherapy* performed there will always be greater risk. It's necessary for us to determine the proper dose of radiation to perform a calculation. So, the concept of radiation dose calculation is a fundamental requirement. However, there are still many people, especially medician who still do not understand this concept because it is hard to understand from existing reference. So, the author made this simple paper.

In this paper will be studied the basic concepts from calculation of the distribution flux radiation for *brachytherapy*. It should be noted that this paper is simple discussion that took over quantity aspect and contour in two – dimentional form. In this paper too, author would give example *brachytherapy isodose* contour curves in cases of cervical cancer with *Manchester* system. Tool used is quite simple, because it is only with *Microsoft Excel*. The author hopes from this simple paper can make people, especially medician easily understand the basic concepts from calculation of the radiation flux distribution in *brachytherapy*. So, from this understanding can create many innovations to make a success of radiotherapy with higher optimization.

II. MATERIALS AND METHODS

A. Coordinate transform to have formula

The method in this study is used coordinate transform to have the radiation flux formulation. The formula used to have contour curves with simple computing in *Excel*. This calculation based on the geometry of various radioactive sources, being brought closer to the point and line. It should be noted that this analyzed just from **quantity** aspect.

Here is a simple calculation to determine the radiation flux distribution from radioactive sources in the geometry of point and line:

a. Point – geometry of radioactive source (S)

Flux density is the number of particles per unit time wide radiation unity [3]:

$$\emptyset = \frac{S}{A_r} \tag{1}$$

with S is the source strength per unit time for a point source and a wide A_r source. Then the radiation flux to a point – geometry of radioactive source, can be given as below [3]:

$$\emptyset = \frac{S}{4\,\pi\,r^2} \tag{2}$$

We must change the formulation into position forms, there are position coordinates *x* and *y*, because it is input that we have from the radiation source and the observer. Here is a figure of the analysis from point – geometry of radioactive source.

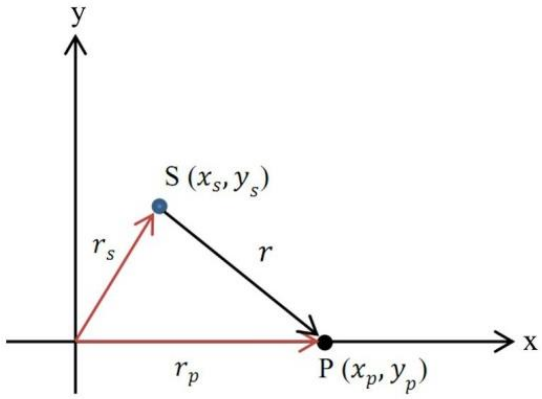

Figure 1. Point – geometry of radioactive source. S expressed source and P expressed Observers point

After we did the decline from general formulation, we will get the radiation flux for radioactive source in point – geometry, which can be given as below:

$$\emptyset = \frac{S}{4\,\pi\left[\left(x_p - x_s\right)^2 + \left(y_p - y_s\right)^2\right]} \tag{3}$$

b. Line – geometry of radioactive source (S_L)

There are three possible positions of the line – geometry of radioactive source; vertical, horizontal and oblique. We must provide boundary conditions in coordinate space in each region. In this paper, author use the orientation of lines in horizontal position. For ease of analysis, we can use the following images:

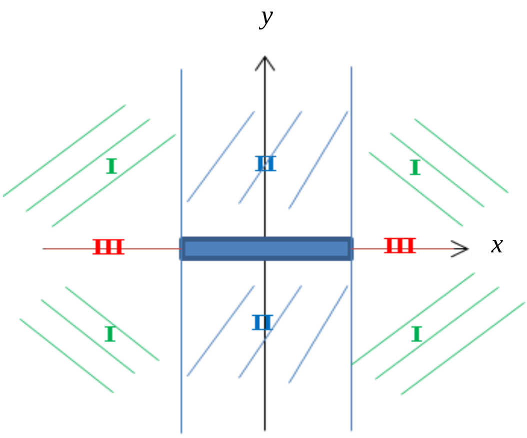

Figure 2. Dividing coordinate space in three region for line – geometry of radioactive source

 # For Region II (P_2)

In the case line – geometry of radioactive source, we take the partition (dx), then the formula of the flux density in region II, becomes:

$$d\emptyset_2 = \left|\frac{S_L\,dx}{4\,\pi\,r^2}\right| \tag{3}$$

with S_L is the source strength per unit time for a point source and a wide A_r source.

Then the radiation flux for radioactive sources in the line – geometry region II, can be given as below [3]:

$$\emptyset_2 = \frac{S_L}{4\,\pi\,h}\left(\theta_2 + \theta_1\right) \tag{4}$$

 # For Region I (P_1)

In the case line – geometry of radioactive source, we take the partition (dx), then the formula of the flux density in region I, becomes:

$$d\emptyset_1 = \left|\frac{S_L\,dx}{4\,\pi\,r^2}\right| \tag{5}$$

with S_L is the source strength per unit time for a point source and a wide A_r source.

Then the radiation flux for radioactive sources in the line – geometry region I, can be given as below [3]:

$$\emptyset_1 = \frac{S_L}{4\,\pi\,h}\left(\theta_2 - \theta_1\right) \tag{6}$$

 # For Region III (P_3)

In the case line – geometry of radioactive source, we take the partition (dx), then the formula of the flux density in region III, becomes:

$$d\emptyset_3 = \left|\frac{S_L\,dx}{4\,\pi\,r^2}\right| \tag{7}$$

with S_L is the source strength per unit time for a point source and a wide A_r source.

Then the radiation dose flux for radioactive sources in the line – geometry region III, can be given as below [3]:

$$\emptyset_3 = \frac{S_L}{4\,\pi}\left(\frac{1}{x_2} - \frac{1}{x_1}\right) \tag{8}$$

The radiation flux formulation for line – geometry of radioactive source that have been presented in the form of the equation is still general equation. We have to change into a form that is the position coordinates *x* and *y*.

In the formulation for line – geometry of radioactive source, author use matrix transformation to make simple calculation. Here is a visualization of the transformation from line – geometry of radioactive source:

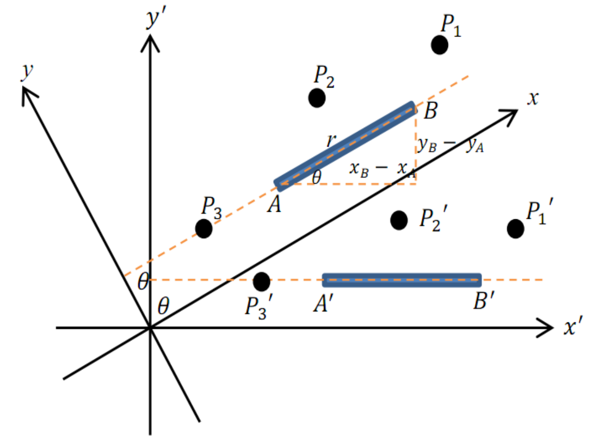

Figure 3. Coordinate transformation in line – geometry of radioactive source

Then, we do the analysis based on the transformation of radioactive sources in the line – geometry horizontal position. Since the coordinate transformation has been performed, then this will apply to the other position of lines. After we did the decline of general formulation, we will get as below:

 # For Region II (*P₂*)

$$\emptyset_2 = \frac{S_L}{4\,\pi\,(y_P' - y_A')}\left[\arctan\left(\frac{x_P' - x_A'}{y_P' - y_A'}\right) + \arctan\left(\frac{x_B' - x_P'}{y_P' - y_A'}\right)\right] \qquad (9)$$

 # For Region I (*P₁*)

$$\emptyset_1 = \frac{S_L}{4\,\pi\,(y_P' - y_A')}\left[\arctan\left(\frac{x_P' - x_A'}{y_P' - y_A'}\right) - \arctan\left(\frac{x_B' - x_P'}{y_P' - y_A'}\right)\right] \qquad (10)$$

The radiation flux formulation for the region I (P_1), if we change the sign bit, then the shape will be the same as formula the dose in region II (P_2), as below:

$$\emptyset_1 = \frac{S_L}{4\,\pi\,(y_p' - y_A')}\left[\arctan\left(\frac{x_P' - x_A'}{y_P' - y_A'}\right) - \left(-\arctan\left(\frac{x_B' - x_P'}{y_P' - y_A'}\right)\right)\right]$$

$$\emptyset_1 = \frac{S_L}{4\,\pi\,(y_P' - y_A')}\left[\arctan\left(\frac{x_P' - x_A'}{y_P' - y_A'}\right) + \arctan\left(\frac{x_B' - x_P'}{y_P' - y_A'}\right)\right] = \emptyset_2$$

We can see that the formulation is given the same with radiation dose region I. It can be analyzed that region I and II are **not in line** with the radioactive source.

 # For Region III (*P₃*)

$$\emptyset_3 = \frac{S_L\;(x_B' - x_A')}{4\,\pi\,(x_B' - x_P')(x_A' - x_P')} \qquad (10)$$

Regional observers test points in the region III (P_3) is an area that is **in line** with the radioactive source.

B. Microsoft Excel for make isodose contours curve

The formulation in the form of position coordinates are used to get the contour curves. Making the curve *isodose* function to see how large doses of radiation emitted from radioactive sources can also be used to see which would be acceptable dose flux distribution to the target volume and critical organs are located in the surrounding [2]. In this discussion, the contour curves obtained using the simple computing in *Microsoft Excel* and displayed in two – dimensional form.

III. RESULTS AND DISCUSSION

Here are some examples of the *isodose* contour curves made with simple computing in *Microsoft Excel*.

a. One point – geometry of radioactive source

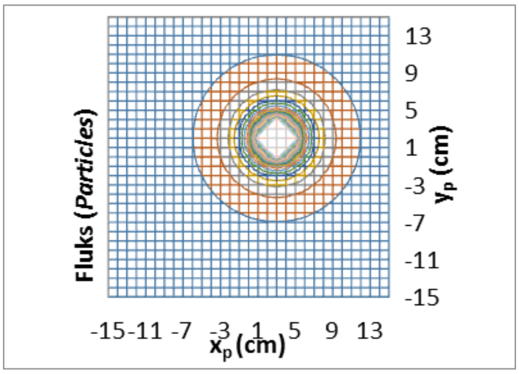

Figure 4. The *isodose* contour curve for a point – geometry radioactive source

If we compare the contour in **Figure 4** with theory in references, we can see that similar with theory.

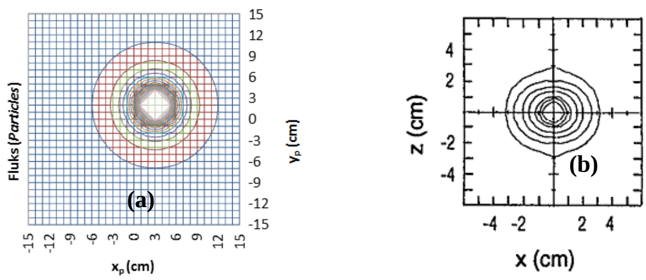

Figure 5. Comparison from *isodose* contours curve for a point – geometry radioactive source based research (a) and theory (b)

The *isodose* contour curve from a point radioactive source to form a circular pattern, similar with in theory.

b. One line – geometry of radioactive source

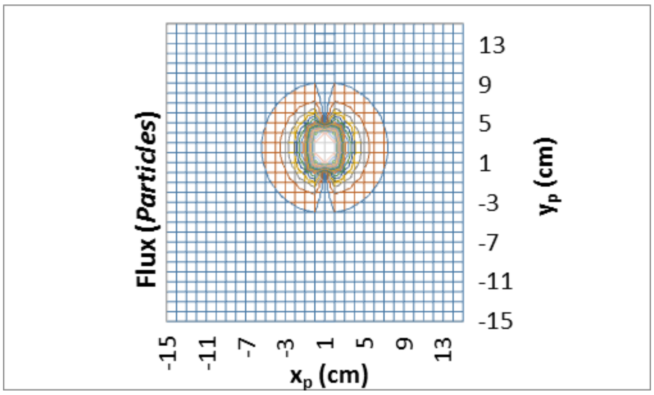

Figure 6. The *isodose* contour curve for a line – geometry of radioactive source

If we compare the contour in **Figure 6** with theory in references, we can see that similar with theory.

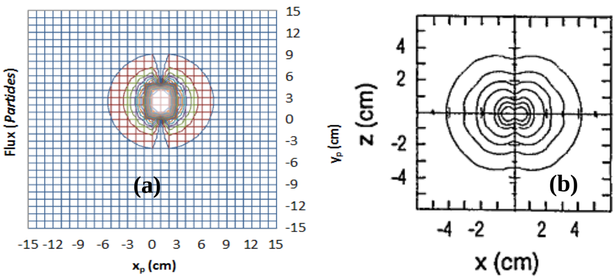

Figure 7. Comparison from *isodose* contours curve for a line – geometry radioactive source based research (a) and theory (b)

The *isodose* contour curve from a line radioactive source patterns shaped like butterflies, similar with in theory.

c. Two point – geometry of radioactive source and three line – geometry of radioactive source

We can also make contour curve from combination of radioactive sources. If we discussion about rule number of seed in the body, we will know the *Manchester* system (Patterson – Parker system). It is the method by implanting seeds. This implant planning system designed to deliver a uniform dose [4]. *Manchester* system gives specific rules of the table presents the distribution of sources and doses for ideal seed placement [5].

The i*sodose* contour curve can be shown as below:

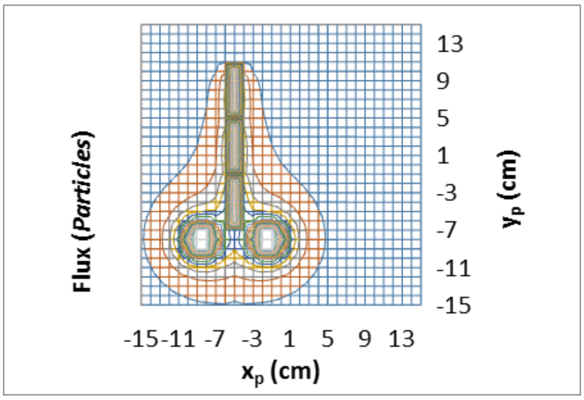

Figure 8. The *isodose* contour curve shapes a pear – shaped used *Manchester* System. Consist of two points – geometry and three lines – geometry of radioactive sources

If we compare the contour in **Figure 7** with theory in references, we can see that similar with theory.

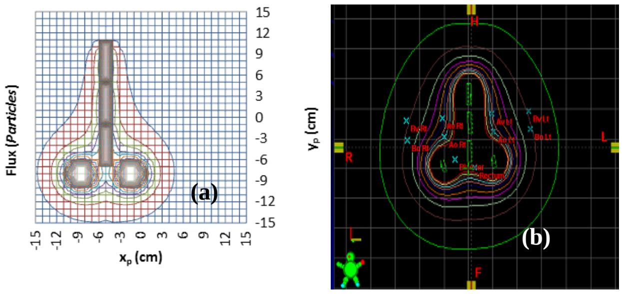

Figure 8. Comparison from *isodose* contour curve used *Manchester* System based research (a) and theory (b)

The *isodose* contour curve above is similar with theory in references, because the same pattern forming pear – shaped. In the reference curves pear – shaped used in *brachytherapy* for cervical cancer. The above contour curves are still very simple, but if we do a quantitative comparison with data in the reference, will we get a similar (quantitative).

IV. CONCLUSION

Calculation of the radiation flux distribution can be created using *Microsoft Excel* and considered quite simple. So, the concept of basic dosimetry in *brachytherapy* can be easily understand for people, especially for medician. This way is very simple and people can easily understand the basic concept of calculate from radiation particle flux distribution.

IV. ACKNOWLEDGMENTS

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