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Artificial Photo-System: Autotrophic Forest Ecosystem in the Design of Pulmonary Tuberculosis Clinic

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***Abstract*— This research is about to design a pulmonary tuberculosis clinic that can reduce the potential spread of tuberculosis germs in the clinic by using nature idea as a support component. Two important aspects of the designs are the prevention of transmission and the comfort aspects of patients in the clinic.**

The prevention aspects of transmission arise from the needs of clinic staff and the convenience aspects arise from the patient's needs. The main problems that arise are low levels of oxygen in the space, as well as aspects of germ isolation to surrounding communities.

Biomimicry approach with *analogy design method* is used as a method to solve problems that arise in the design of clinic. The *analogy method* is supported by the *descriptive method* of Nigel Cross to find the main problems of the building.

The autotrophic plant analogy was used as an idea to solve the problem of oxygen levels in space with the concept of artificial photo-systems and the analogy of petals used as an idea to solve the problem of the spread of germs.

Keywords: Pulmonary tuberculosis, Clinic, Biomimicry, Analogy design method, oxygen level, autotrophic plant, petals.

I. INTRODUCTION

A. Research Background

Indonesia became the second highest ranked country for tuberculosis positive cases worldwide [1]. One of the factors causing the increase of tuberculosis patient is the lack of public health service facility. It needs a lot of supporting facilities in overcoming tuberculosis bacteria in health facilities such as centralized ventilation system, negative pressure system on space, ultraviolet germicidal irradiation (UVGI), UVGI upper air and high-efficiency particulate air (HEPA) air filter system. it takes a huge cost for the facility, while the health clinic does not have sufficient funds to fulfill the facility. Limited funds in health clinics make the development of clinical facilities and the installation of special ventilation to support the prevention of infectious diseases is very limited [2].

Natural factor is one of alternative in prevention of bacterial transmission with limited of clinical development cost. Direct sunlight can kill pulmonary tuberculosis bacteria in 5 minutes [3]. Natural factors can also provide psychological support to patients called healing architecture.

The application of natural elements in architecture called Biomimicry. The concept of biomimicry is the development of inspirational ideas from nature and their transfer to create sustainable design solutions. Animals, plants and microbes are skilled engineers. They have found something that works, something worthy and most importantly, something that goes on earth [4]. Biomimicry takes the concept of nature to solve problems in buildings using analogy design method, and supported by descriptive model method from Nigel cross for problem analysis. The process of identification of mimicing objects is focused on the natural functions that can solve the main problems in the design such as the analogy of autotrophic plants and analogy of petals.

The design result is the concept of schematic design and drawing from tuberculosis clinic which is able to prevent transmission of pulmonary tuberculosis by using the analogy of autotrophic plants to solve airflow problem, and the analogy of petals to solve the problem of transmission of tuberculosis germs through building mass. It is hoped that the concept can be applied to other health facilities, so it can support reduce the risk of transmission in health clinics.

B. Research Location

The location of the pulmonary tuberculosis clinic is in the region of north Surabaya precisely in the District Semampir, Pegirian village, Karang tembok street. site selection is influenced by the number of tuberculosis sufferers in sub-districts of Surabaya and associated with the number of health facilities in each of these areas.

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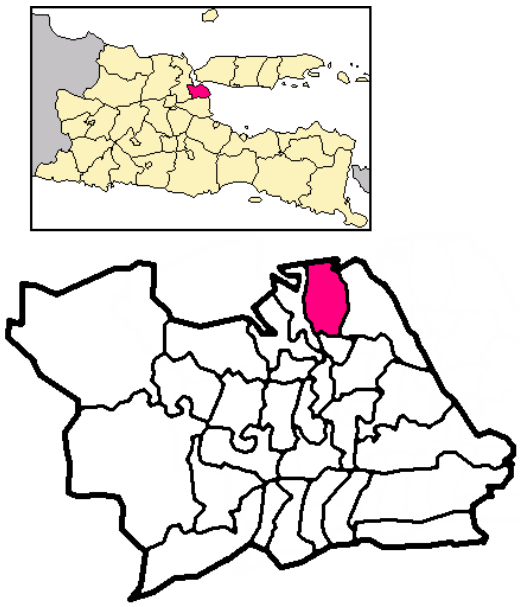

Fig.1 District Semampir as a Location of Clinic

Areas of high vulnerability of tuberculosis are found in Wonokromo, Sawahan, Semampir and Tambaksari districts [5]. The comparison of the number of health facilities in district Semampir has fewer ratios with other districts with similar areas (Tambaksari and Wonokromo). District Semampir need an additional health facilities to support the prevent spreading process of disease in the area.

Tabel 1 Analysis Location

District	Area (KM^2)	Health Facilities Around
Semampir	8,76	• PHC Hospital • PKU Muhammadiyah Hospital • Al-Irsyad Hospital • Pulmonari Hospital of Surabaya
Tambaksari	8,99	• Dr. Soetomo Hospital • Husada Utama Hospital • DR M Soewandhie Hospital • Adi Husada Hospital
Wonokromo	8,47	• Naval Hospitals Surabaya • Bhakti Rahayu Hospital • Darmo Hospital • Pura raharja Hospital • William Booth Hospital • Siloam Hospital
Sawahan	6,93	• Darmo Hospital • William Booth Hospital • Brawijaya Hospital • Mitra Keluarga Hospital

II. LITERATURE REVIEW

A. *Tuberculosis clinic*

Clinic is a health service facility that conducts individual health services that provide basic and/or special medical services [6]. Special room facilities at Tuberculosis Pulmonary clinic is a patient tuberculosis test facility in the form of chest X-rays and microscopic sputum tests. A thoracic test was performed on the x-ray chamber while a microscopic sputum test was performed in the laboratory.
The health clinic room program is divided into 3 main components ie administrative group, patient service and service[7]. Combination of spesific room & the literatur data, the space program that is formed is Administration (Lounge & reception area, Business [registration, book keeping, insurance, staff], Medical records), Patient services (Examination of the patient, Consultation), Service (Nurse station, Warehouse & Staff lounge) and Special facilities (X-rays, & Laboratory).

Tuberculosis is a contagious disease directly caused by mycobacterium tuberculosis. The specific properties of mycobacterium tuberculosis include:

- Mycobacterium tuberculosis quickly dies with direct sunlight and can survive for several hours in dark and humid areas. These germs can fall asleep in tissues for several years [8].
- The doubling time of mycobacterium tuberculosis bacteria was 12 hours or more and progressed well at 22 ° C [9].

B. *Healing Architecture*

Failure of a person's adaptation process to his environment, can cause psychological stress, especially in someone who is ill (patient). Psychological stress in the patient is very influential on the healing process. The healing concept is useful in balancing medical healing with the patient's internal potential. This implementation will appear in the final state of patient health, ie reduction of care time, reduction of medical expenses, pain reduction, stress reduction, positive mood arousal, uplifting, and increased patient expectation in the environment [10]

Healing architecture elements can appear by presenting the following elements:

- Natural lighting : The patient's position toward sun exposure is related to the depressed level of the patient. Patients with sun exposure from the east have less hospital time than patients with exposure to the sun from the west
- Colour : The ability of colors to affect the psychological can be utilized to provide a positive support on the psychological patient, so that the psychological condition of patients to be better.

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C. Biomimicry

The concept of biomimicry is the development of inspirational ideas from nature and their transfer to create sustainable design solutions. Nature serves as a model, mentor and measure to promote the design of sustainable innovation, not just material sources. Nature is an aspect that contains a strategy of survival for a very long time, so that the basic concept contained in nature is the result of natural adaptation process by testing directly by the environment itself [11].

Biomimicry approach is divided into two [11]:

- Biomimetic Design Process Stages-From a Problem to Biology : the approach begins by identifying the problem to be solved, then looking for the concept of the organism from nature with the ability to solve the problem.
- Biomimetic design process stages-from biology to an application: approach begins by choosing the concept of organism from nature that has unique characteristics, then looking for the concept of problems that can be solved by the concept of the organism.

Biomimicry is divided into three different categories or "levels"; organisms, behaviors, and ecosystems[12]. Within each level there will be a possible dimension of mimicing. A design can be biomimetic in terms of forms, materials, how the design is constructed, how it works or what the design can do.

D. Authotroph Ecosystem

Ecosystem is the smallest unit that has complete ecological component, has complete ecological niches, and there is complete ecological process, so that in this unit the cycle of matter and energy flow occurs according to ecosystem condition[13]

Autotrophs are organisms that are able to **provide / synthesize their own food** in the form of organic materials from inorganic materials with the help of energy such as solar and chemical. The autotroph component serves as a producer, for example green plants [14]. An autotroph plant is a type of plant with the ability to produce food independently through the process of photosynthesis with the help of sunlight. In general, autotrophic plants have a green leaf substance (chlorophyll) as a condition in the process of photosynthesis. The special parts of the autotroph plant are leaves (Epidermal tissue, Mesophyllal tissue or parenchyma and Transport carrier network) and flowers (rhacis, pedicellus, receptaculum and perianthium [**Calyk/Petal**,corolla, Perigonium])

Petals (Calyk) That part of the flower jewelry which is the outer circle of flowers, generally green. at the time the flowers are still buds, the petals are the veil that serves as a protective bud against the influence from the outside.

E. Photosynthesis of Autotrophic Plants

Photosynthesis is the process of preparing organic substances H2O and CO2 into complex organic compounds with the help of sunlight. Photosynthesis can only occur in plants that have chlorophyll, the pigment that serves as a catcher of sunlight energy.

Photosynthesis is the process of forming organic compounds (C6H12O6) from inorganic compounds (CO2 and H2O) by chlorophyll with the help of sunlight. The stages in photosynthesis are sequences of the process of capturing light energy (photosystem), electron flow, and the process [15].

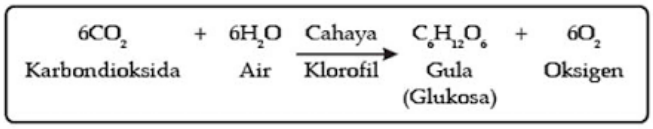

Fig.2 Fotosynthesys process

III. METHODOLOGY

This design combine two method to make a new combination method. The frist method is a descriptive model by Nigel cross [16] and the second method is a Analogy biomimetic method by Yael Helfman Cohen [11]. The main method is a analogy method and the descriptive model method serves as a support method in the analysis of main problem.

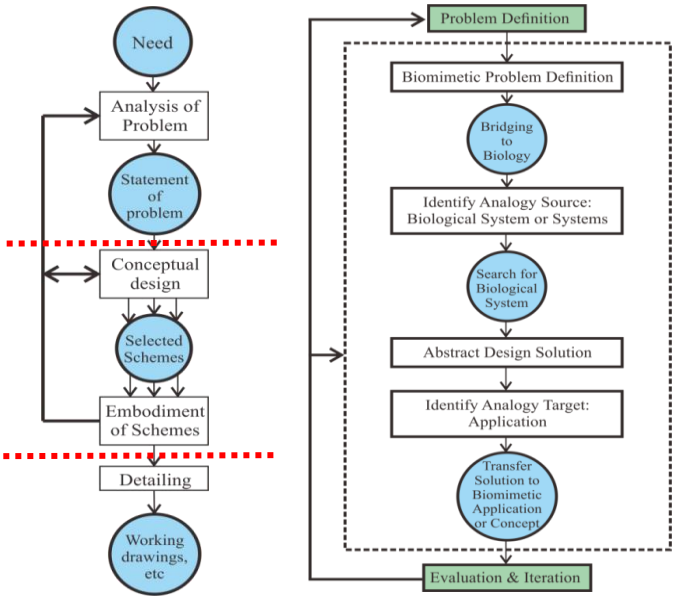

Fig.3 Descriptive method & Analogy Method

Combined method design process:

1. Descriptive Method
   - Need
   - Analysis of Problem
   - Statement of problem
2. Analogy Method
   - Problem Definition
   - Biomimetic Problem

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- Identify Analogy Source
- Abstract Design Solution
- Identify Analogical Target: Application
- Evaluation & Iteration

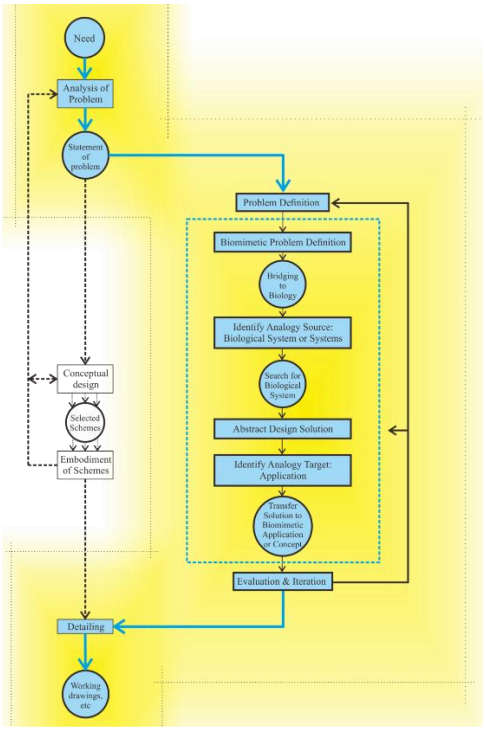

Fig.4 Combined Method

IV. RESULT AND DISCUSSION

Design criteria arrise from the analysis of need from the user of the building, using descriptive method to extrace the main problem of the pulmonary tuberculosis clinic.

A. Descriptive Method

Tabel 2 Descriptive Design Process

Design Process	Aspect	Doctor (prevention of transmission TB)	Patient (Comfort)	Status
Need	Airflow	Airflow is required to provide an indoor air change cycle so that germs can get out of the room.	Strong air flow can force the patient's lungs to make more strenuous efforts to inhale the oxygen in the room.	Not Support
	Natural Lighting	Direct exposure to sunlight is needed in the process of killing germs in the room.	avoid excessive heat arising from natural lighting	Not Support
Analysis of problem	• Airflow: Doctors recommend the use of airflow to clean the air in the room from the TB germs, but airflow disturbs the patient's breathing • Natural Light: doctors recommend the use of natural light to kill germs, but the heat arising from natural lighting reduce patient comfort			
Statement of problem	• Airflow: increase the supply of oxygen into building that makes air flow can run without disturbing the patient's breathing • Natural Lighting: the process of killing the germ occurs outside the building with the help of airflow as a dirty air steering media out of the building			

B. Design Criteria

1. Airflow should contain rich oxygen, so patients can get adequate oxygen supply at low air intake intensity.
2. Natural lighting plays a role in killing tuberculosis germs in buildings.

C. Analogy Method

Tabel 3 Analogy Design Process

Design Process	Airflow	Natural Lighting
Probem Definition	Increase oxygen levels in buildings	Supports the isolation aspect of germs and directs germs into the sun
Biomimetic Problem	Biology concept/ide that can produce oxygen	Aspect of tuberculosis germ protection so as not spread out area
Identify Analogy Source	Analogy of the autotroph plant (Artificial Photo-system)	analogy of petals (Calyk)
Abstract Design Solution	Utilize the process of photosynthesis to produce oxygen and channeled into the room through the airborne system	The insulating aspect of flower petals is used to constrict the airborne dispersal of germs to the surrounding environment
Identify: Application	Building airflow system	Building Form
Evaluation & Iteration	• It takes direct sun exposure to support the process of photosynthesis • It takes autotroph plants as a process of photosynthesis media • It takes media to control the oxygen the result of photosynthesis process.	The concept of isolation will withstand air in the area and potentially increase transmission in the clinic area

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D. Design

1. Artificial Photo-system (Airflow)

The criteria that must be met is the availability of abundant oxygen in space. The abundant oxygen in the room will support the respiratory process of the affected patient due to the air flowing in the room. By increasing oxygen in space, the controlling aspects of transmission in the presence of indoor air circulation can be applied in space without disturbing patient comfort.

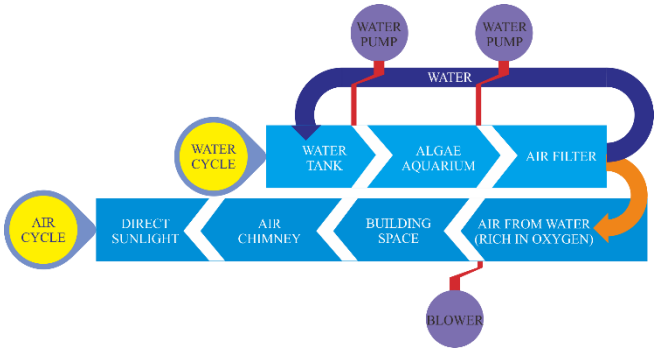

Fig.5 Photo-system Cycle

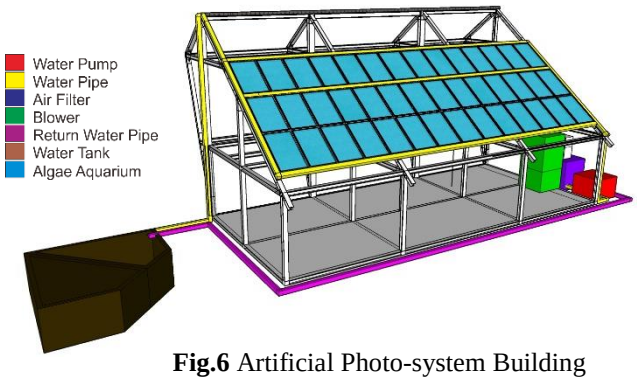

Fig.6 Artificial Photo-system Building

The fact that arises in autotrophic forest concepts and is related to oxygen problems in space is the ability of autotrophic plants to produce oxygen through photosynthesis processes that can support oxygen supply in space.

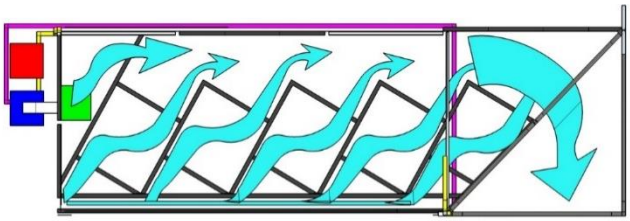

Fig.7 Airflow Inside the Building

2. Analogy of Petal (Building Form)

The idea of the structure of the petals component is based on the protection aspect of the petals on the flower crown during the bud flowers. The concept of flower petals is the basis of the formation of building masses, in addition to other supporting aspects that encourage the formation of building mass.

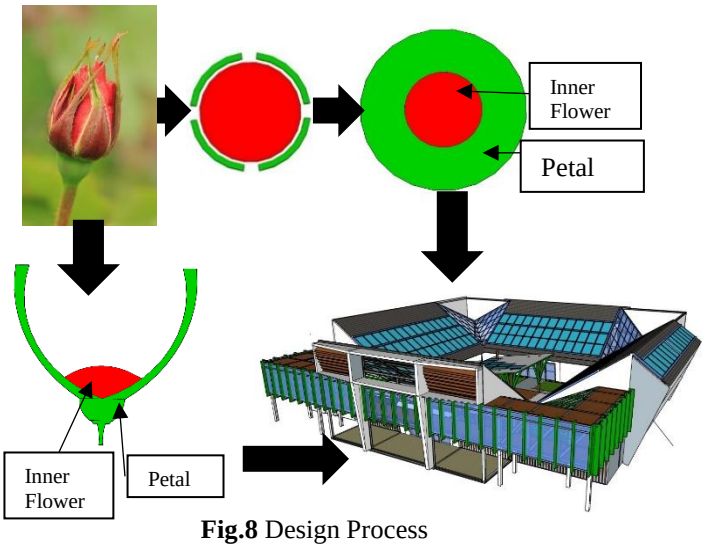

Fig.8 Design Process

Fig.9 Plan 1

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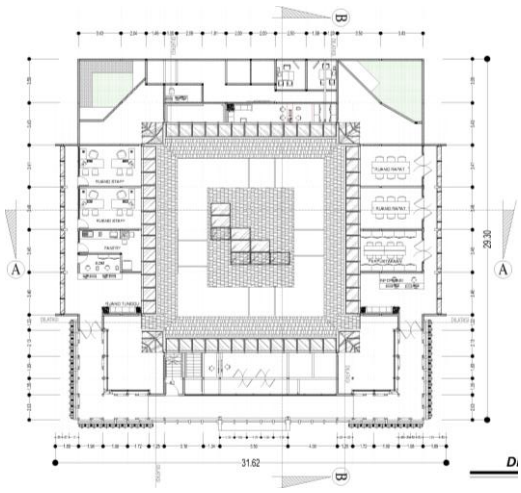

Fig.10 Plan 2

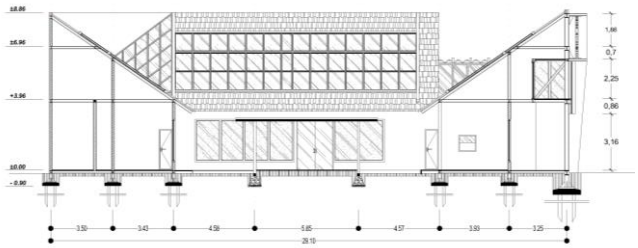

Fig.11 Section

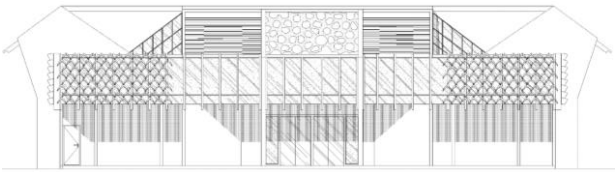

Fig.12 Building Facade

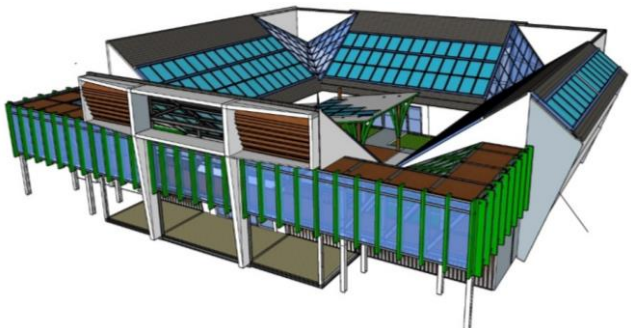

Fig.13 Perspective

V. CONCLUSION

The design responds to the needs of the building in tackling the transmission of tuberculosis by presenting the concept of airflow in the building and presents a formation that supports the elimination of germs with the help of natural lighting developed from the analogy petals

Building construction supports the patient's comfort by increasing oxygen levels in the building through an artificial photo-system concept that developed from the analogy of the autotrof ecosystem, so that patients can breathe comfortably and prevention efforts can run in the presence of airflow in buildings.

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