

# ROOF GARDEN RECYCLING MODEL (RGRM): ALTERNATIVE TECHNOLOGIES FOR LOW COST, FRIENDLY RESIDENTIAL IN LIMITED AREA URBAN ENVIRONMENT AND OPTIMIZING RECYCLED MATERIALS<sup>4</sup>

Achmad Suryadi<sup>\*1</sup> and Agustina Setiawati<sup>\*2</sup>

<sup>1</sup>Undergraduate Student, Library and Information Science, University of Indonesia,

E-mail: achmad.suryadi91@gmail.com

<sup>2</sup>Graduate Student, Hospital Management, University of Indonesia

E-mail: agustinasetiawati@yahoo.com

## Abstract

Urban activity gives contribution on global warming. The density of urban society led to the need of space for the people, like residential and building as a center of their activity. On the other hand, this case rise ecology problem that is the decreases of green open field. Eco-friendly residential development becomes new paradigm. Roof Garden (RG) emerges as a new breakthrough to answer the lack of urban field by designing the roof of the building to become multifunction garden for reforestation and watershed. 1 m<sup>2</sup> of RG filters 0,2 kg particles of dust aerosols and smoke each year, reduces the reflection of sound up to 3-8db, cools the building surface up to 27 °C and saves electricity consumption 50-70%. However, the high cost of RG construction make few people implemented it, this problem show that the technology is less effective. We need alternative technology to develop RG with low cost.

We propose Roof Garden Recycling Model (RGRM). Basically, it is the same concept as the general RG. The differences is in the planting container used, RGRM use outworn materials that can still be utilized. Total rubbish produced by the people all the world reaches 1.3 billion tons per year and predicted rising 70% in 2025. Glass bottles, plastic bottles, tires, newsprint, old pipes and broken glass is a waste that can be recycled into RGRM components that easy, inexpensive and environmental friendly. This material saves energy and reduces air pollution up to 95%. The material obtained from waste materials in household consumption makes it low cost. With its advantages, RGRM is a solution. Using green technology, it is an alternative in creating friendly environmental residential based on RG by utilizing recycle materials.

**Keywords:** Urban Society, Global Warming, Eco-Friendly Residential, Roof Garden, Recycling Model, Recycled Materials

## Introduction

### Urban Issues and Global Warming

The population of world citizen continues to increase rapidly for last 2 millennial. In 1999, the world population passed six billion people. In 2011, the numbers of world population are estimated to reach 7.021.836.029. The growth rate is currently about 1.3% and going to double in 54 years. This amount placed 10 countries as the highest population country, China, India, US, Indonesia, Brasilia, Pakistan, Nigeria, Bangladesh, Russia and Japan. From 10 countries, Tokyo is the most crowded city in the world with 3.41 million people, followed by Mexico City, Seoul, New York, Sao Paulo, Mumbai, Delhi, Los Angels, Shanghai and Jakarta as the tenth city with population around 17.150.000 people.

The increasing amount of urban population is directly proportional with the increasing of human needs for living space followed by the increasing of infrastructure and facilities needs to support human life, including schools, offices, hospital and other supporting facilities. It can be seen from the existence of green land and buffer zone is under the threat as the effect of large land conversion scale for the importance of provision land that has high land rate designated for residential, industrial and shopping center. The growth of high urban population also has direct impact on global warming. Nowadays, the average of urban household has contributed approximately 3 kg of waste per day; on the other hand the threat of land conversion from development is going to increase. In Indonesia predicted about 60% of the population (160 million populations) of urban areas in 2025.

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<sup>4</sup> This paper be presented at The 5<sup>th</sup> Indonesia Japan Joint Scientific Symposium (IJSS) 2012 (Japan, October 25<sup>th</sup> 2012)

It means, there will be an increase in urban waste volume that implies the increasing of global warming. Reflecting this phenomenon, the concept of eco-friendly housing becomes a new paradigm in urban communities. Roof Garden has emerged as a breakthrough in order to answer the problem of the lack of urban land to manipulate the building roof into a multifunctional garden for planting and water inflation.

### **Roof Garden: Implementation, Benefits and Weakness**

Roof Garden (RG) is a model of landscape that has existed since ancient Mesopotamia in the 4th Century. According to the International Green Roof Association (IGRA), RG has 9 benefits such as (1) RG may increase roof and building endurance (2) RG can reduce the sound reflection up to 3 db (3) RG vegetation can reduce air temperature, make coolness and comfort in the room (4) Offers various function and usefulness for the utilization purpose (5) RG vegetation may become natural habitat for animals and plants that have been lost due to the reduction of green areas (6) RG growing media can reduce rainfall by 50-90% (7) Reduces the effect "Urban Heat Island Effect" that is discomfort feelings that emerge because temperature difference between the city and the suburbs, especially in the summer (8) 1m<sup>2</sup> RG can filter 0.2 aerosol and roof particle every year (9) Beautify monotonous city with flowers and shady trees RG can also cool the building up to 27°C so that can reduce the use of AC which has implications for power consumption savings.

The potency of the technology application in urban environment is very high. RG can be made by all levels of society, both individual in the house scale and developers in wider scale. Certainly, the fineness is not primary purpose (objective), but safety should also be priority both for users and for construction underneath. Therefore, RG must fulfill several requirement like good protection for the roof and the structure, has good and safe drainage system, light cropping media and able to adapt to the weather. RG commonly used components such as waterproof membrane, drainage layer, a thick layer of soil, vegetation and landscaping although some are equipped with thermal insulation, vapor control, growing medium and support panels. Completeness of this component depends on the type of RG has chosen, there is Intensive and Extensive RG. With variety benefits, RG has been implemented in several countries such as Australia, China, Japan, Canada, US and others.

RG presence begin decorate a major city in the world, but RG has not create qualify environment because the limitation amount of the building, a massive residential has not touched. The lack of RG utilization can be caused by several things, first the limitation of public knowledge, the lack of law enforcement from the government and in

Indonesia, people consider the application of RG is expensive and the process of installation and maintenance is complicated. Certainly, this case is quite reasonable. The cost of RG construction can spend money between IDR 500.000 - 1.000.000 per m<sup>2</sup>. It means, this technology is less effective from the financial side. The application of RG particularly in developing country like Indonesia has two challenges. First, is the limited number of expert in Indonesia that able to install RG, second, most of Indonesia's population is the middle-lower citizen, because of the financial condition of the majority Indonesian, they can not afford RG installation and the continuous cost of RG maintenance. This condition is exacerbated by Indonesia geographical position that located in the Circum Pacific and earthquake troubled, so that the cost of RG installation is expensive because the building foundation and roof technology, should be more consideration and use specific techniques. Therefore, in order to anticipate the high cost of the RG construction. We offer the idea as an alternative technology to optimize the use of household garbage that potential to be recycled into RG components which is cheaper, easier to get and friendlier environment.

## **Result**

### **Roof Garden Recycling Model (RGRM)**

Basically, RGRM is the same like general RG. But the difference is in planting container used or in the packaging. RGRM utilize materials that are not used but still has utility value. The purpose of choosing recycled material as plant container in RGRM technology is certainly to reduce the cost of manufacturing RG to be as cheap as possible so that this technology can be reached by any society, especially among the people of the city with a medium level of finance.

Recycling is the process of reusing an object rather than throw it away, as a new product not waste, but it can reduce energy consumption. Total waste produced by people around the world to reach about 1.3 billion tons per year and is predicted to continue to rise by 70% from this year to 2025. This is great opportunity to develop technology-based RGRM waste utilization. Glass bottles, plastic bottles, cardboard, newsprint, glass pipe and glass fraction is rubbish that can be recycled into RGRM building component easy, cheap and friendly environmental. This material is able to save energy and reduce air pollution up to 95%. In this discussion we use quantitative calculation of the economic approach to prove that by using RGRM technology with recycled component can save RG development cost. We analyzed the cost and the component that RG and RGRM needs as a comparison, this is our analysis.

The figure 1 below, we can see the differences in the number of component in two types

of RG. There are more components in intensive roof garden than in extensive roof garden. This case affects the cost in making RG. The main components are structural deck, waterproofing, protection layer, drainage layer and filter layer.

While, the component such as lightweight soil and top soil are optional component, it's depending on the type of RG we will build.

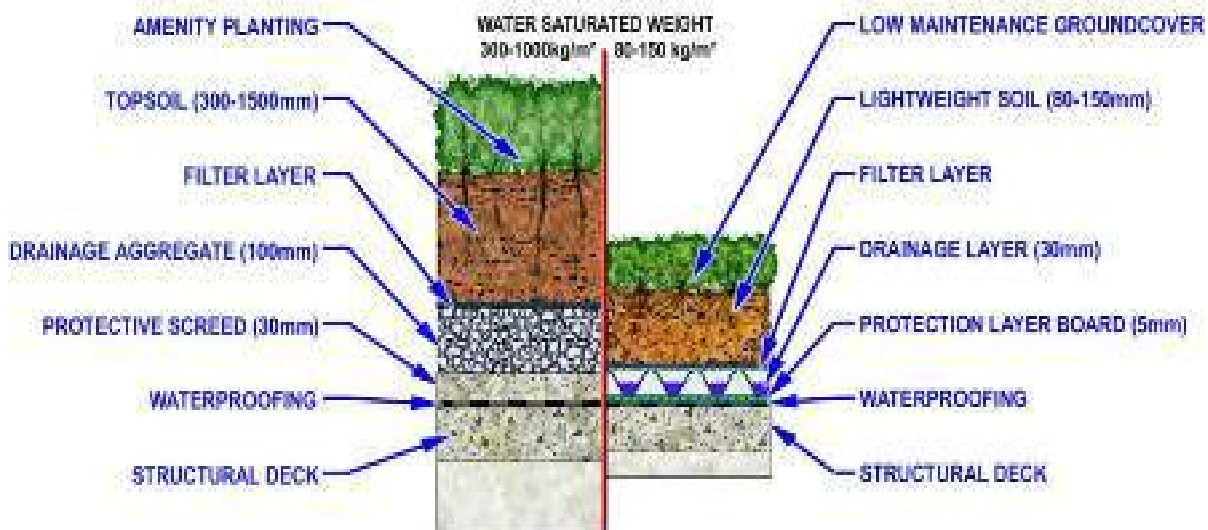


Figure 1. Layer Component of RG (Townshend, Derek. Source and copyright © Urbis Ltd., 2006)

This is the estimated cost of making RG and the material commonly used:

Table 1. Cost Estimation of Manufacturing RG (modification from Mahardika, 2002)

| Component               | Cost Estimation per m <sup>2</sup> |                        |
|-------------------------|------------------------------------|------------------------|
|                         | Minimum                            | Maksimum               |
| Soil Medium (2-3 mm)    | -                                  | -                      |
| Filter Layer (0,6-2 cm) | 30.000/m <sup>2</sup>              | 50.000/m <sup>2</sup>  |
| Drainage Cell (3-7 cm)  | 289.000/m <sup>2</sup>             | 343.000/m <sup>3</sup> |
| Cement Protective Layer | 25.000/m <sup>2</sup>              | 35.000/m <sup>2</sup>  |
| Waterproofing Layer     | 25.000/m <sup>2</sup>              | 60.000/m <sup>2</sup>  |
| Concrete Floor Slop     | -                                  | -                      |
| Total                   | 369.000/m <sup>2</sup>             | 488.000/m              |

The estimation above can be used for house that already has concrete roof. Waterproofing layer usually made of asphalt whose function is to protect the roof concrete and can be hardened as the time passes. The protective layer function is to protect waterproofing layer from the mechanical disturbances such disorder from roots. In this case, we could use cement and fiberglass. Drainage layer serves to discharge water infiltration. Made by polystyrene or can be granular materials such as gravel or stone chips. The most expensive cost compared to other components. Filter layer function is to filter soil particle, so it's not enter the drainage layer and the usual type of non-woven geotextile.

After we calculate the total cost of making RG, we got range from IDR 360.000 - 488.000 per m<sup>2</sup>. From this calculation we initiated the alternative solution to cheaper RG in its application. The technology of RGRM emphasizes the RG component can be replaced by using the recycled household waste and maximize the function, RGRM

designated to maximize the use of recycle material and can adjust to various forms of residential roofing, both sloping roofs or roofs with concrete. The materials needed are:

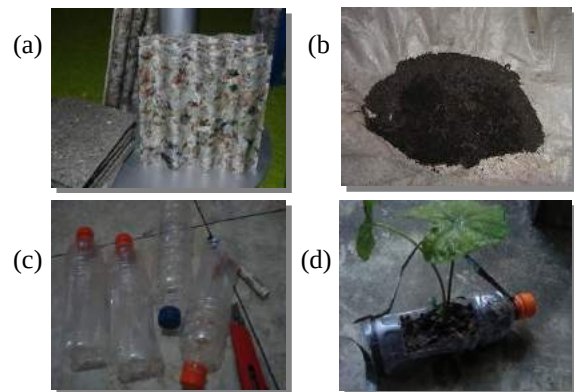


Figure 2. (a) Polynum Poly Roof (lumbung usaha), (b) Husk Fuel (tabloid gallery), (c) Plastic Bottles (Kusumawati), (d) Plate Containers of Plastic Bottles (Kusumawati)

The composition of RGRM materials consist of Polynum Poly Roof, bendrat wire, plastic bottle and husk fuel. Layer from recycle aluminum roof called tetrapak or Polynum Poly Roof, a friendly environmental product from the beverage package and recycle become polyblock or polyroof. It looked like asbestos, usually wavy. In Indonesia, the roof is usually called Tetrapak. The advantage of this roof are (1) light (2) unbreakable (3) flame retardant (4) more healthy and environmentally friendly. This layer has the same function like waterproofing layer, the function is to protect the building, and even this layer does not need to be

attached to the roof of the building. Roof shape is not always flat, but also with sloping shape it would be great because it can make gravitation and help water drainage to flow naturally.

For container planting, we can use a plastic bottle. Plastic bottles include goods that are difficult to unravel, but instead it can be used as a durable container planting. The advantage of using a plastic planting container are (1) economical (2) strong and durable (3) easy to set up. We can get it easily from collecting junk or used our own beverage consumption. First, form the plastic bottle, which is perforated upper vertically. Plastic bottle that has been done, paste it on the roof by using a parallel wire but without linking it to the roof, attached to another bottle so they mutually reinforcing.

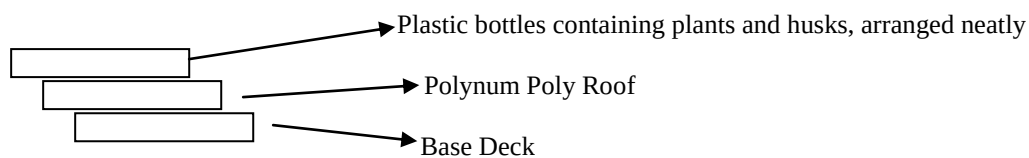


Figure 3. Materials Structure of RGRM

Plastic bottles arranged in parallel and use a wire to corroborate the bottle each other, so that the roof will look like the following figure:

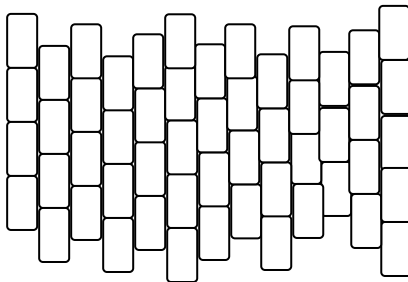


Figure 4. Plastic Bottles Arrangement

Based on this purpose, we calculate the total cost of which is used to build this RGRM as described in the following table:

Table 2. Estimation Cost of Manufacturing RGRM

| Component                 | Cost Estimation per m <sup>2</sup> |                       |
|---------------------------|------------------------------------|-----------------------|
|                           | Minimum                            | Maksimum              |
| Soil Medium (2-3 mm)      | -                                  | -                     |
| Polynum Poly Roof         | 41.500/m <sup>2</sup>              | 55.000/m <sup>2</sup> |
| Bendrat Wire              | 13.000/m <sup>2</sup>              | 15.000/m <sup>2</sup> |
| Plastic Bottle (5 pieces) | -                                  | -                     |
| Husk Fuel                 | 1.500/m <sup>2</sup>               | 5.000/m <sup>2</sup>  |
| Concrete Floor Slop       | -                                  | -                     |
| Total                     | 56.000/m <sup>2</sup>              | 75.000/m <sup>2</sup> |

Based on the table it can be seen to build RGRM estimated price ranging from IDR 56,000 to IDR 75,000 per m<sup>2</sup>. Compare this with the cost of making the general RG that could reach IDR 488 000 per m<sup>2</sup>. Thus it can be interpreted that to create environmentally friendly residential RGRM implementation can save up to IDR 432,000 per m<sup>2</sup>

The selection of planting container based on the requirement that growing media must give sufficient nutrition to the plant. Husk fuel can be a choice because husk fuel contains SiO<sub>2</sub> (52%), C (31%), K (0.3%), N (0.18%), F (0.08%), and calcium (0.14 %). Besides that husk fuel also contain other elements like Fe<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO, CaO, MnO and Cu in small amount as well as several types of organic materials. High content of silicates make plants more resistant to pests and diseases. High pH husk fuel can prevent weeds and bacterial populations. Additionally, husk fuel has a low ability to absorb water and good porosity so drainage could be better. The composition of the roof material illustrated in the following figure:

or equivalent to 88% cost savings compared to RG in general.

## Conclusion

Our idea to create RGRM is the application of green technology to create RGRM friendly housing environmental by considering three main aspects cheap, optimize and friendly environment. Recycled materials as the main component manufacture of RGRM, making this technology as visible technology, because the cost of recycled material preparation is low and by using recycled materials from our waste household it can be free and make it friendly environmental because can reduce waste discharge. Not only that, if this technology can change become a mass movement, for example "One House One RGRM" it can be predict, RGRM can create thousands of eco-friendly residential in the crowded city. This means in certain period, RGRM not only control the microclimate, but also control the macroclimate and natural cool air. RGRM is an alternative solution that we offer in creating friendly housing environmental in a limited urban land by creating innovation in RG become cheap and optimize recycled material.

## References

- Adi, Wendy Mustika. 2011. Taman Atap (Roof Garden): Sejarah Manfaat dan Aplikasinya. <http://campuraduk-gadogado.blogspot.com/2011/03/taman-atap-roof-garden-sejarah-manfaat.html>, 12 September 2012
- Anderson, McRae. Design and Development of a Roof Garden. Saint Paul: Mc Caren Desain Inc.

- Anonim. 2011. Fungsi dan Kandungan Arang Sekam. [http://www.sehatcommunity.com/2011/11/fungsi-dan-kandungan-arang-sekamsekam\\_2106.html#axzz26DliPWeu](http://www.sehatcommunity.com/2011/11/fungsi-dan-kandungan-arang-sekamsekam_2106.html#axzz26DliPWeu), 12 September 2012
- Anonim. 2012. Tepung sekam padi. <http://buysellonindonesia.blogspot.com/2012/03/tepung-sekam-padi.html>
- Apsari, Juwita. 2007. Kajian Pengembangan Roof Garden di Metropolitan dalam Upaya Mengatasi Fenomena Urban Heat Island (Case Studi : DKI Jakarta) [skripsi]. Bogor: Bogor Agricultural Institute
- Dirgantara, I Ketut. 2010. Identifikasi Penggunaan AC dengan Roof Garden dari Segi Biaya. <http://www.scribd.com/doc/31798208/Identifikasi-Perbandingan-Penggunaan-Ac-Dengan-Roof-Garden>, 12 September 2012
- D'Errico, Carla. 2010. Green Roofing Options. <http://buildipedia.com/go-green/sustainable-materials-methods/green-roofing-options>, 12 September 2012
- Ecolife. Ecolife: A Guide to Green living, Definition of Recycling. <http://www.ecolife.com/define/recycling.html>, 12 September 2012
- Joe. 2010. Green Roof: Alternatif untuk Meredam Dampak Pemanasan Global. <http://joe-proudly-present.blogspot.com/2010/05/green-roof-solusi-bagi-pemanasan-global.html>, 12 September 2012
- Kusumawati, Edi. 2012. Memanfaatkan Botol Plastik Bekas Minuman untuk Pot Tanaman. <http://green.kompasiana.com/penghijauan/2012/07/10/memanfaatkan-botol-plastik-bekas-minuman-untuk-pot-tanaman/> 12 September 2012
- Livingroofs. 2004. A reports for sustainable Eastside: Green Roofs Benefits and Cost Implication. Birmingham: Livingroofs.org
- Mahardika, Akbar Putra. 2002. Studi Karakteristik Roof Garden di DKI Jakarta (Case Studi: Kondominium Taman Anggrek dan Apartemen Roxy) [skripsi]. Bogor: Bogor Agricultural Institute
- Pelupessy, Ried. 2012. Roof Garden. <http://riedm.blogspot.com/2012/05/roof-garden.html>, 12 September 2012.
- Permana, Indra Jaka. 2010. <http://www.ideaonline.co.id/idea/peralatan-dan-bahan-bangunan/artikel/bahan-bangunan/atap-gelombang-dari-bahan-aluminium-kemasan-daur-ulang/>, 12 September 2012
- Permata, Besi. 2012. Harga Kawat Paku. <http://lambungusaha.wordpress.com/2011/04/04/polynum-m-polly-roof/>, 12 September 2012
- Rosenberg, Matt. 2006. Largest Cities in The World-List Two. <http://geography.about.com/od/urbaneconomicgeography/a/agglomerations2.htm>, 9 September 2012
- Rosenberg, Matt. 2011. How fast is the world's population growing. <http://geography.about.com/library/faq/blqzworldgrowth.htm>, 9 September 2012
- Rossenber, Matt. 2011. Most Populous Countries Today. <http://geography.about.com/cs/worldpopulation/a/mostpopulous.htm>, 9 September 2012
- Rossenber, Matt. 2012. Current Wold Pupulation. <http://geography.about.com/od/obtainpopulationandata/a/worldpopulation.htm>, 9 September 2012
- Tabloidgallery. 2008. Sekam Bakar Bagi Adenium. <http://tabloidgallery.wordpress.com/2008/07/04/s-ekam-bakar-bagi-adenium/>, 12 September 2012
- Towshend, Derek. 2007. Architectural Services Department Study on Green Roof Application in Hongkong Final Executive Summary: Urbish Limited
- Usaha, Lumbung. 2011. Polynum Poly Roof. <http://lambungusaha.wordpress.com/2011/04/04/polynum-polly-roof/>, 12 September 2012

### **Keterangan Penulis**

Achmad Suryadi adalah mahasiswa Semester 4 Program Studi Ilmu Informasi dan Perpustakaan, Fakultas Ilmu Pengetahuan Budaya Universitas Indonesia. Penerima Beastudi Etos ini pernah aktif di BEM dan DKM FIB UI dan saat ini aktif di Majelis Wali Amanat UI Unsur Mahasiswa. Beberapa prestasi yang pernah diraih antara lain peraih dana Hibah UI Young Creative Entrepreneur 2012, 10 Besar Karya Tulis Ilmiah STQ Universitas Indonesia 2012, Penulis Rubrik Suara Mahasiswa Media Nasional SINDO dan Republika, dan Delegasi Debat Bahasa Indonesia kontingen FIB dalam Olimpiade Ilmiah Mahasiswa Universitas Indonesia 2012

Agustina Setiawati adalah mahasiswi lulusan program Vokasi Universitas Indonesia bidang studi Kedokteran tahun 2009. Aktif berorganisasi sejak duduk di bangku SMA diantaranya mengikuti kegiatan English Club dan ikut serta dalam beberapa kompetisi Bahasa Inggris. Saat di bangku kuliah, Agustina menyalurkan semangat kontribusinya dengan aktif di FOKSI, sebuah lembaga dakwah tingkat fakultas. Kegiatan di luar kampus yang dijalani Agustina diantaranya mendampingi anak-anak lingkungan sekitar rumah dalam kegiatan belajar secara cuma-cuma.