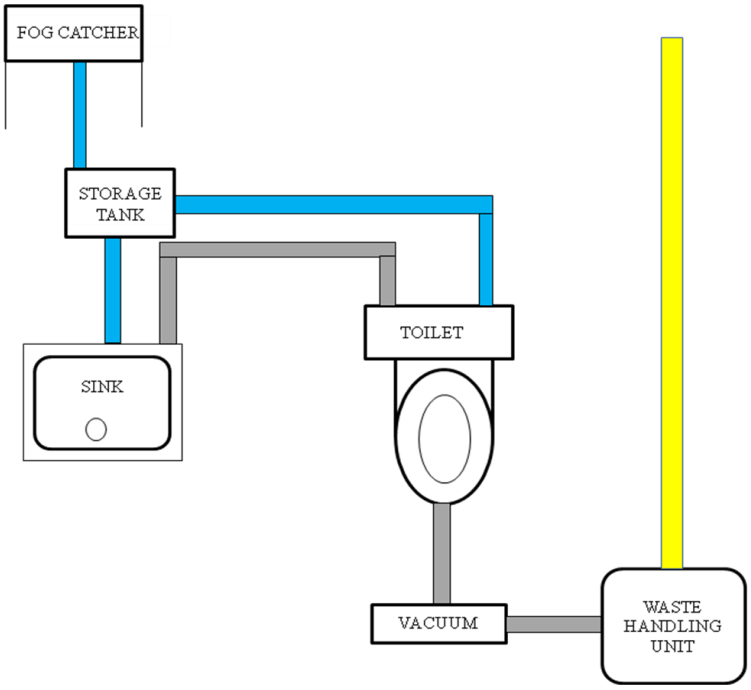
Vacuumposter

(*Submission to Blue Responsibility Award: Manufacturing for a Sustainable Terra Preta Sanitation System*)



Contributed by:

Solid Mechanics League, Universiti Tun Hussein Onn Malaysia

Sustainable Materials and Manufacturing League, Universiti Teknologi Malaysia

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ABSTRACT

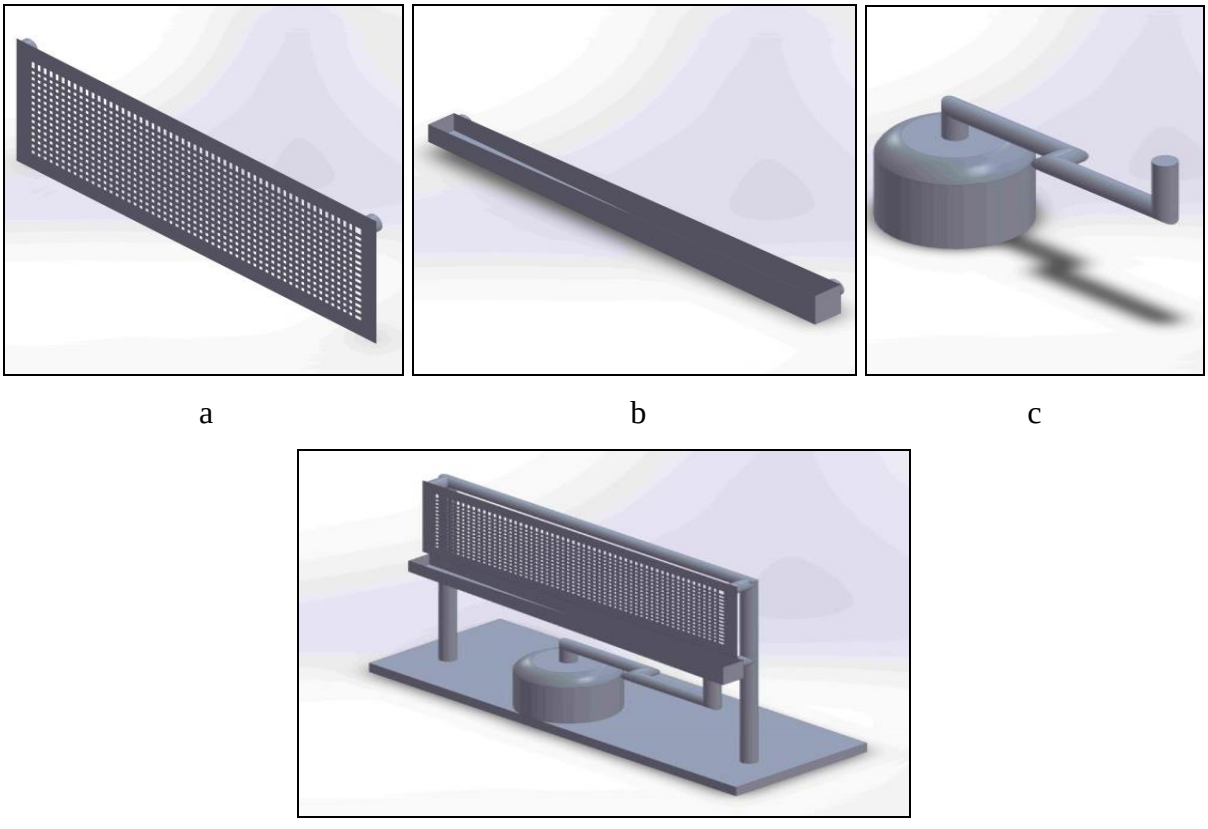
The proposed sanitary system consists of a water supply, a toilet, and a waste handling unit. For the water supply, the system is integrated with fog condenser system installed outdoor, especially on the roof/top of the building unit. The fog condenser supplies clean water to the sink and to the toilet's flush water tank. To maximize the use of the clean water, the sink's drain is connected to the toilet's flush water tank. For the toilet, vacuum flush concept is adapted. The vacuum flush toilet uses minimum amount of water to flush which benefits in two ways: conserving the water use and easier excrement handling. During flushing, water is released from the flush water tank, the vacuum valve on the outlet of toilet bowl is opened, and the vacuum pump sucks the water and excrement to the waste handling unit. The toilet is designed to enable squatting posture with movable squatting supports. The waste handling unit consists of a container with vents of vertical pipe ended at the roof/top of the building. The container is a composting unit of the building or collective container in the neighborhood. The composting unit uses aerobic bacteria for proper composting, avoiding foul odor, and to contain plus immobilize pathogens. This sanitation system may consist of single toilet or multiple toilets for use in a single household. The composting unit can be installed within the building unit or collectively in the neighborhood.

1. TECHNICAL DESIGN

The proposed sanitary system has three main components: water supply unit, toilet, and waste handling unit. This sanitation system is designed to be applicable for single toilet and also for multiple toilets in a single building or multiple toilets in multiple buildings.

1.1 Water supply unit

Fog catcher is one of the main components in water supply unit. It will be placed on top/roof of the building. The condensed water is stored in storage tank, to be distributed to sinks and to the toilet's flush water tanks. The fog catcher consists of net (hold by vertical poles on its sides), gutter, and storage tank (Figure 1). The rectangular net of fog catcher usually made from fine mesh of nylon or polypropylene.



a b c

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Figure 1. Schematics of water supply unit: (a) net, (b) gutter, (c) storage tank, and (d) schematics after installation.

The mechanism of a fog catcher is as follows. Fog will be trapped between the net and tiny fog droplets will accumulate to form large drops and then fall into the gutter by the gravity

and into the storage tank. There are few factors that affect the quantity of water extract from the fog:

a) frequency of fog occurrence
b) fog water content
c) design of fog water collection system

The advantages by using this fog catcher as water supply system are:

a) no energy is needed to operate this system
b) low cost
c) easy to maintain and repair
d) easy installation

Table 1 shows the technical specification of this fog catcher, based on Malaysia's climate.

Table 1. Fog catcher system

Item	Description
Net material	nylon or polypropylene
Net size	12 m long x 4 m high
Collecting surface	48 m^2
Water production rate	150 – 170 L/day
	*depends on the collecting site
Lifespan	2 years
Storage tank	50% of the expected maximum daily volume of water consumed

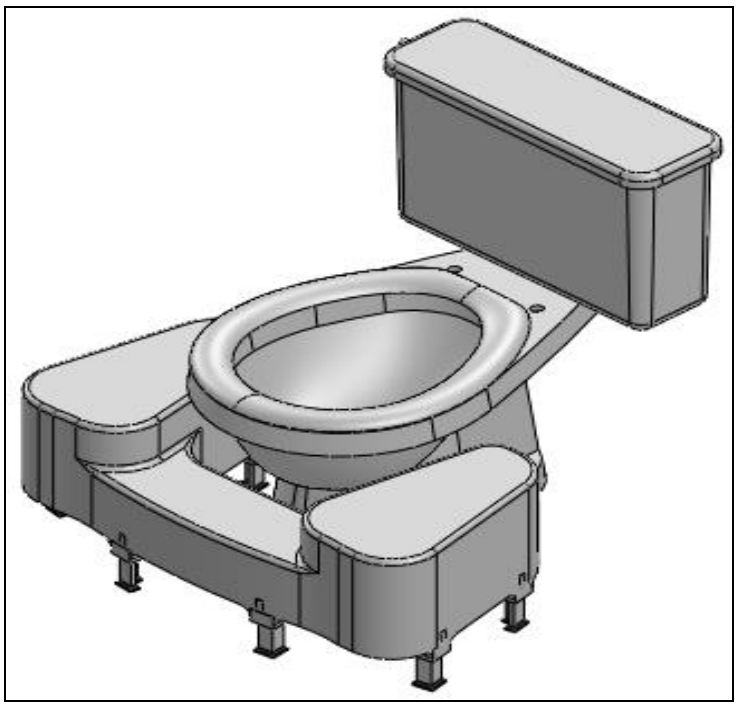
1.2 Toilet

The toilet design features adjustable squatting support. Some medical case studies show that squatting is the natural way to achieve easier and more complete elimination. Squatting posture allows easier defecation. Therefore, a movable squatting supports is attached below toilet bowl to enable squatting posture. The height of the support is designed to be adjustable to suit different age groups and different heights of users. Table 2 summarizes the squatting support specification.

The toilet bowl's surface is coated with silane that has fluorinated hydrocarbon substituent. This coating makes the surface become hydrophobic (water repellent) and oleophobic (oil

repellent). The hydrophobic and oleophobic coating is used to avoid excrement adherence to the toilet bowl, to facilitated flushing, and to ultimately minimize water use.

During flushing, water is released from the flush water tank, the vacuum valve on the outlet of toilet bowl is opened, and the vacuum pump sucks the water and excrement to the waste handling unit.



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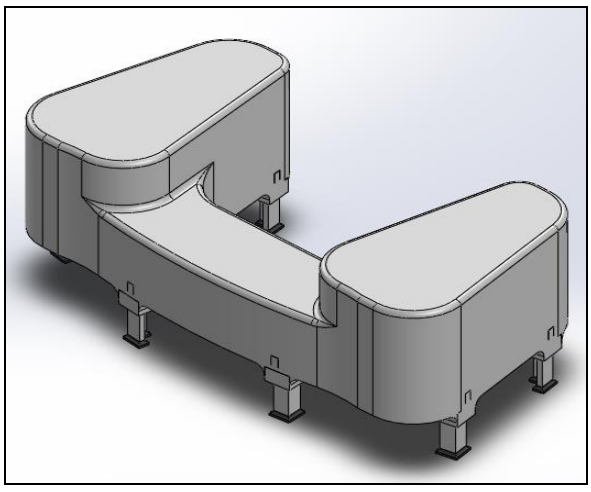

b

Figure 2. Schematics of the toilet with squatting support (a) and the squatting support (b).

Table 2. Squatting support specification

Item	Description
Material	Polypropylene
Dimension	(913.53 x 470 x 280)mm
Adjustable High	280mm to 364mm

1.3 Waste handling unit

For a close loop of human nutrition, human excreta should return to the soil. However, human excreta cannot directly return to the soil since it potentially contains disease-causing organisms called pathogens. Therefore, the container of waste handling unit is designed to function as composter of the excrement for primary treatment and decrease pathogens. The vertical ventilation pipe that ended at the top of the building unit facilitates the passage of air and allows excess moisture in container to evaporate. The containment period of excrement in collection chamber is about 6-12 months. During this period, the pathogen levels will be reduced as a result of storage time, decomposition, dehydration, increased pH, and the presence of other organisms and competition for nutrients. The waste handling unit can be stored at a place having direct sun light since solar heating can further increase pathogen immobilization.

A vacuum pump is placed nearby the container to suck water and excrement from toilet. The use of vacuum is expected to reduce significantly the use of water to flush the toilet. However, the use of vacuum can also be eliminated. The consequence is to enlarge the toilet tank (or use the commercially available toilet tank), and to double the capacity of the composter. This system without vacuum pump is suitable for uses in minor areas where electricity can be a problem, to eliminate the use of electricity in the system altogether, and to reduce the initial cost for the system.

The composter is a composting unit of the building or collectively container in the neighborhood. Envirolet® concept is adapted in designing the composter in waste handling unit (Figure 3). Specification of the waste handling unit is mentioned in Table 3.

Table 3. Specification of the waste handling unit

Item	Description
Capacity	8 people/day (vacation use) 10 people/day (full time use) *Based on 3 uses per person per day
Power supply	120 VAC electric (north American model) 230 VAC electric (Scandinavian and Europe model)

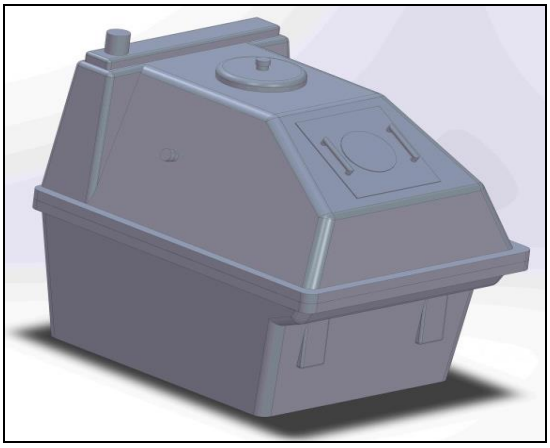

Figure 3. Schematics of composter in the waste handling unit.

Overall schematics of the installed sanitation system for single toilet is displayed in Figure 4. For multiple toilets, the schematics is displayed in Figure 5.

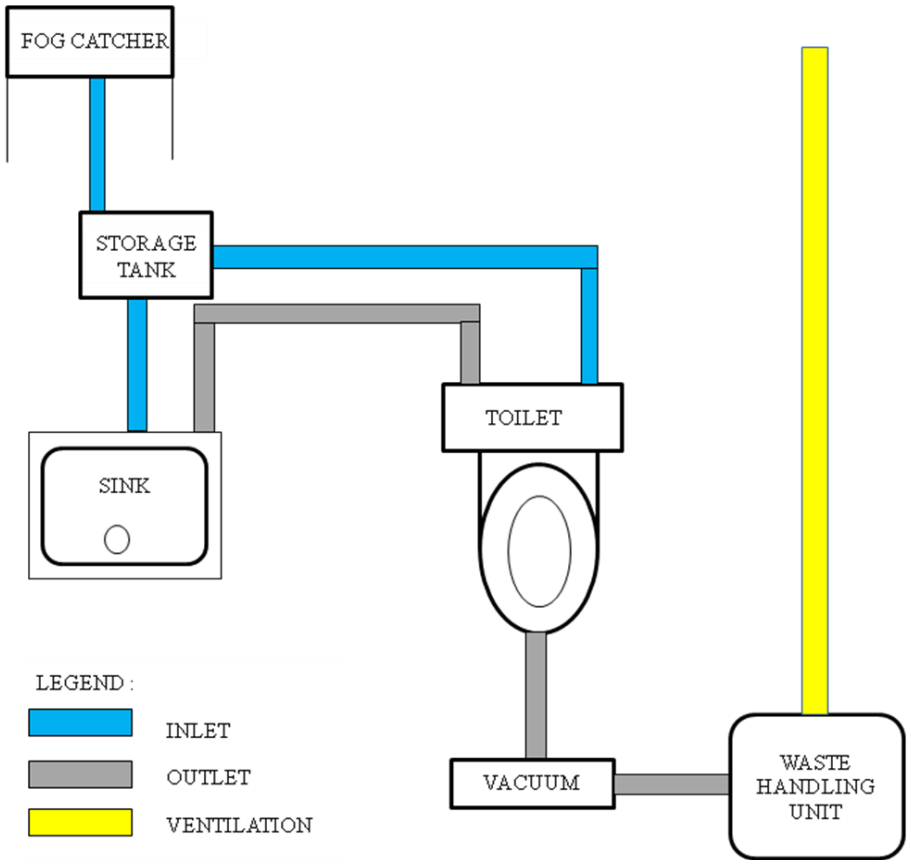

Figure 4. Schematics of single toilet sanitation system.

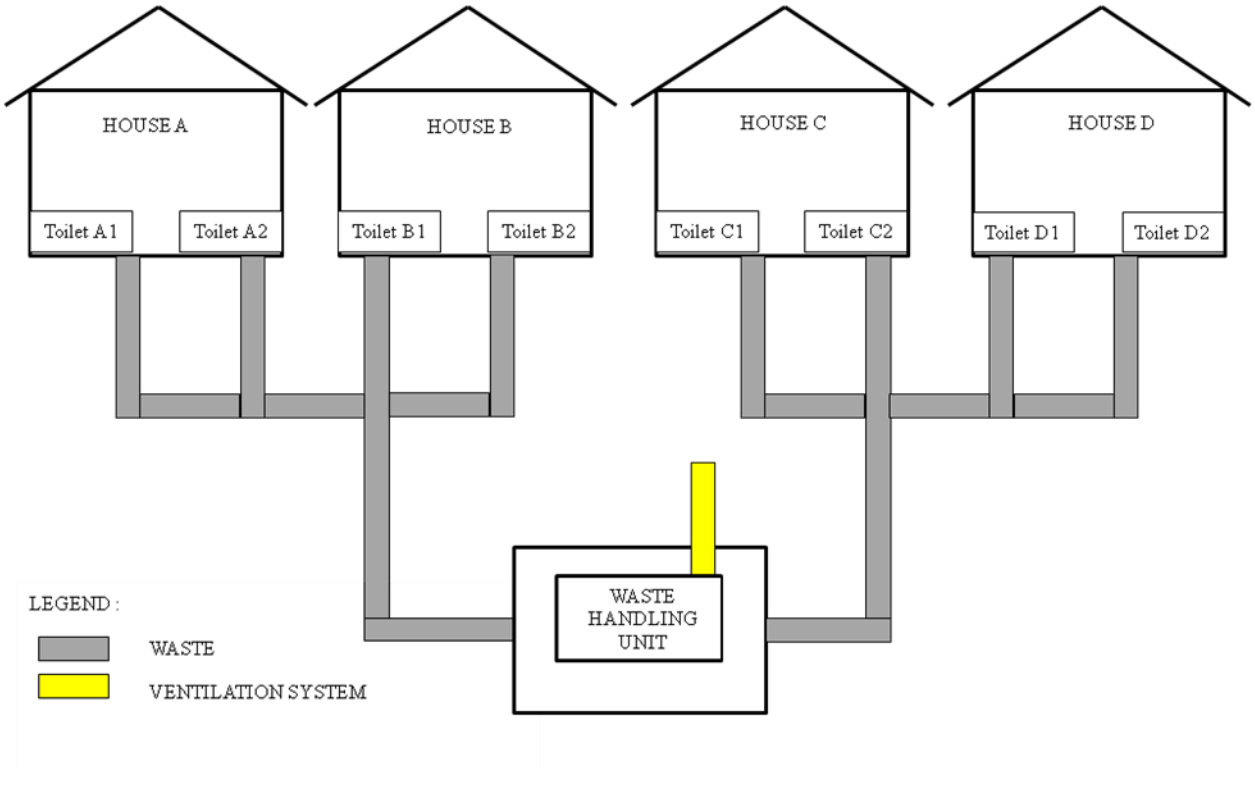

Figure 5. Schematics of multiple toilets sanitation system.

2 SUSTAINABILITY CONSIDERATION IN THE DESIGN

For the sanitation system, the sustainability and environmental consideration are as below:

- Avoid the excessive use of elbows, sockets, and bends pipe for piping connection from water supply unit to toilet's water tank and from toilet to waste handling unit. As a result it may reduce maintenance cost to clear the obstructed piping and thus minimize materials used in this system.
- Fog condenser is designed to supply water to toilet's water tanks and sinks so that more clean water can be conserved. The water used for flushing should come from grey water from sink. Clean water from storage tank is only used for flushing when grey water supply is insufficient.
- Current sanitation system flushes away the human excreta to the sewage system and thus to the river. Such system contaminates and pollutes river. This requires more manpower and resources to solve the problem. Taking this problem into account, a waste handling unit is therefore designed to store and compose human excreta.
- The excrement in waste handling unit is reusable after the proper treatment. This nutrient-rich compost can treated as fertilizer and supplied to local farmers for their crops. In long term, the demands of chemical fertilizers will be declined and more energy and resources are saved.
- Priority selection on manufacturing process with low energy consumption and water consumption.

3 BUSINESS MODEL

3.1 Cost estimation

The cost estimation for the designed sanitation system is mentioned in Table 4. The estimate is based on 1 toilet unit. For multiple toilet units (up to 10 toilet units in single or multiple buildings), the number of toilets should be adjusted. For the next 10 toilet units, the number of waste handling units should be adjusted.

For uses in minor areas where electricity can be a problem, or to eliminate the use of electricity in the system altogether, the vacuum pump can be eliminated. This causes the composting unit must be doubled in capacity. Still, total cost for waste handling unit can be reduced up to 60% this way.

Table 4. Cost estimate of the sanitation system

Item	Item	Specification/ Dimension	Quantity	Price/Unit [RM]	Total price [RM]
	Water supply				
1	Polypropylene net	Area: 48m^2	1	5/m^2	240
2	PVC Gutter	12m	1	10/m	120
3	Storage tank	1000L	2	500	1000
	Toilet				
4	Adjustable squatting support		1	200	200
5	Ceramic toilet		1	600	600
6	Toilet tank		1	100	100
	Waste handling unit				
7	Vacuum pump	230VAC	1	4000	4000
8	Compost unit		1	1000	1000
				Total	7260

Note: Total cost above does not include installation and maintenance costs and electricity for vacuum pump.

3.2 Value creation

The cost estimate for the sanitation system is considerably higher than regular toilet. The additional cost comes from the water supply and waste handling units. To put it in Malaysia context, water tariff is free or almost free (RM 5 per 20kL), sewerage service is low (RM8/month). Also, cost for handling and transporting compost is expected to be higher than the value of the compost (due to the small amount of compost). These mean the proposed sanitation system is not commercially feasible. The negative investment value can be reduced when this system is installed in densely populated areas, like apartments, offices, schools, stadiums, and markets. So, for a start, this system can be installed in those facilities.

Due to this nature of sanitation system, this negative investment can and should be regulated or borne by the governments. The mechanism can be through:

a. Deduction of house ownership taxes when the sustainable sanitation system is installed.
b. Disincentive by increasing sewerage service fee.

c. Introducing new tax or utility bill for the use of sanitary system. This way, government must bear/subsidize the installation and maintenance, and in return the house owner must pay the sanitation bill.
d. Initial fund for the sanitation system in a region/housing estate can be obtained from Corporate Social Responsibility funds from local industries. In return, the industries are allowed to do product/brand placement and use the sanitation system for their advertising media. For example, the net (which is huge in size) is a kind of banner for outdoor commercials. Also, the toilet which is visited at least once every two days for about or over 3 minutes is a perfect media to put advertisement.
e. For rural and minor areas, the initial fund can be obtained from CSR funds, nongovernmental organizations, and various charities. Public participation in installation, handling, and maintenance is required. This public participation is the substitute for the new utility (sanitation) bill imposed to urban households.

Notes:

- The proposed sanitation system is still at conceptual phase.
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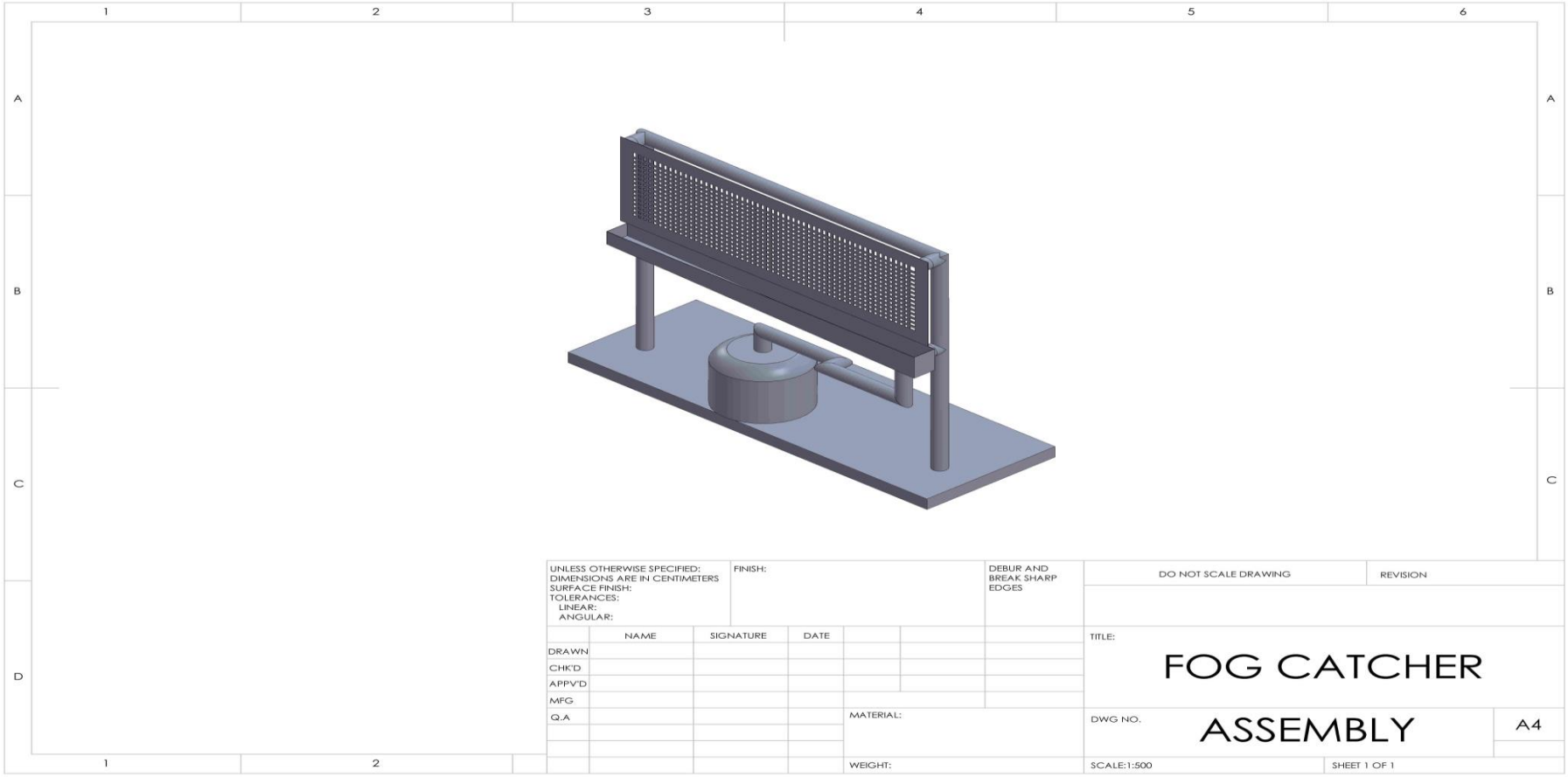
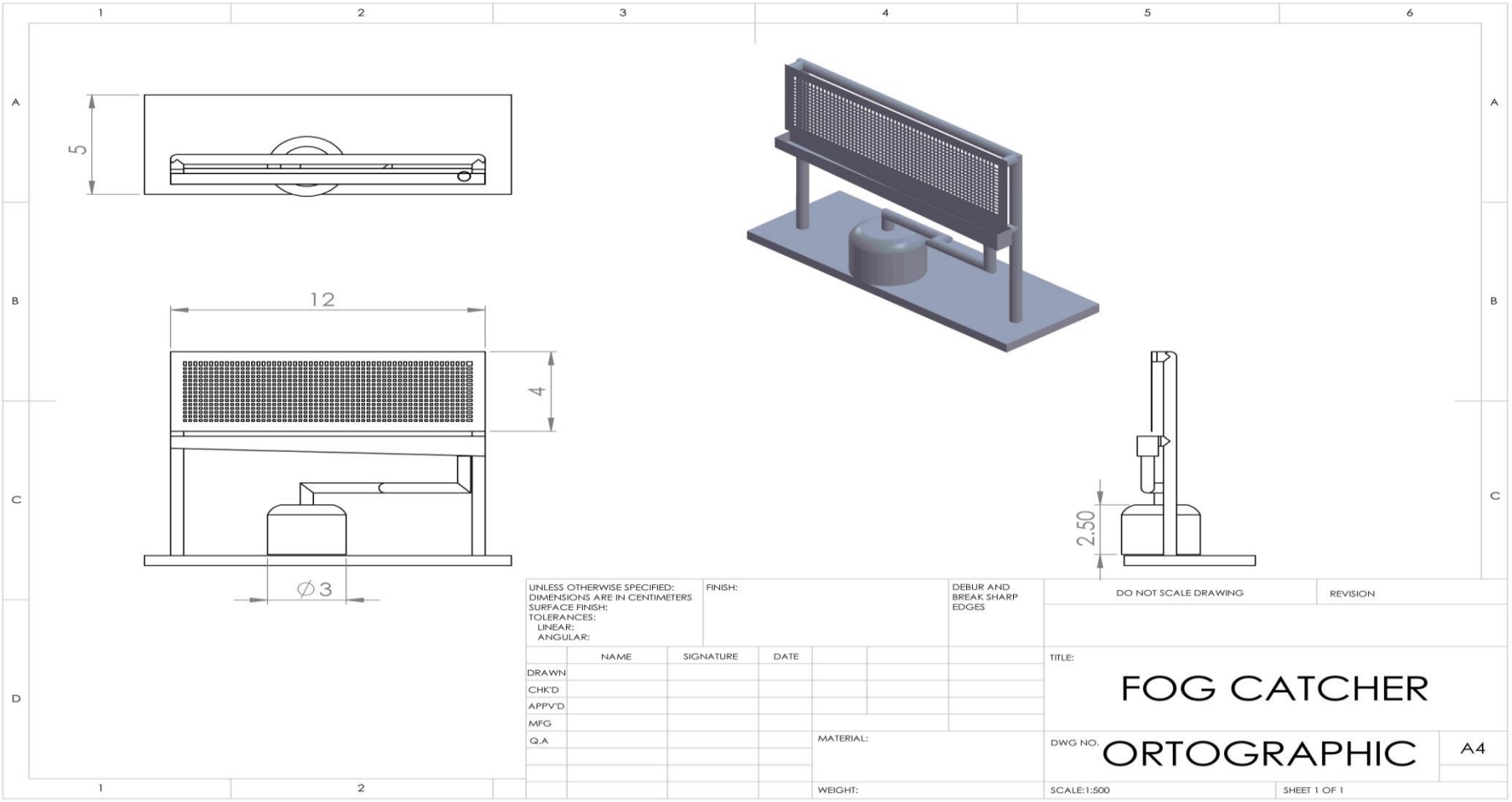
APPENDIX

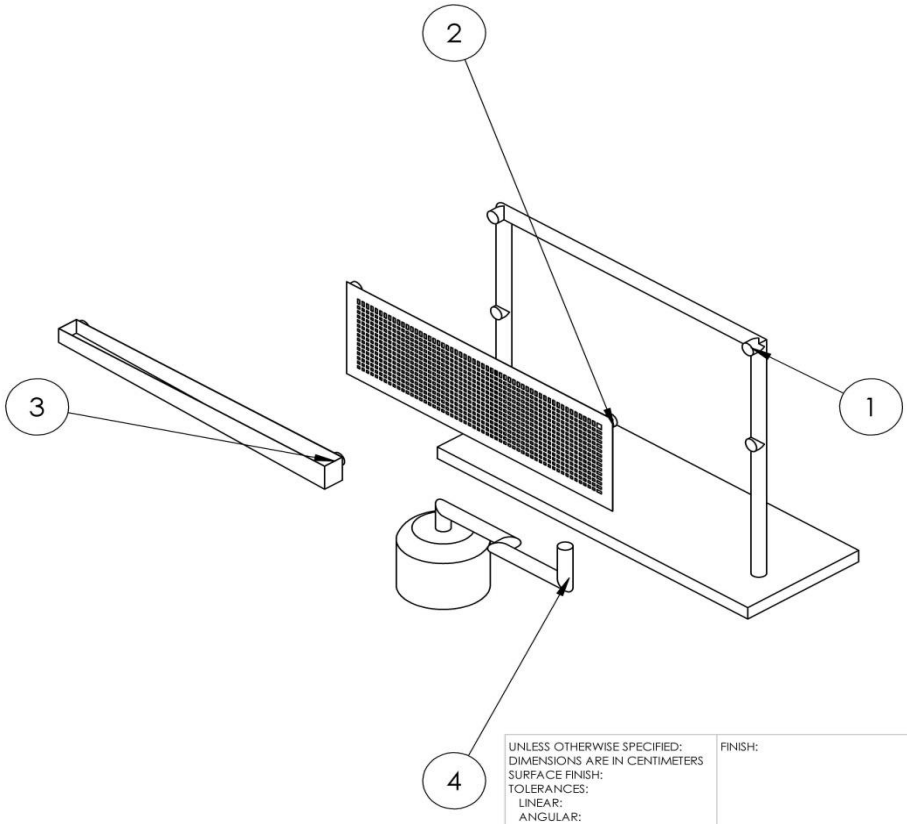


**DIMENSION IN METER (M)



**DIMENSION IN METER (M)

ITEM NO.	PART NUMBER	QTY.
1	frame	1
2	net	1
3	gutter	1
4	tank and pipe	1



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN CENTIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:			DEBUR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE:	
DRAWN						FOG CATCHER	
CHK'D							
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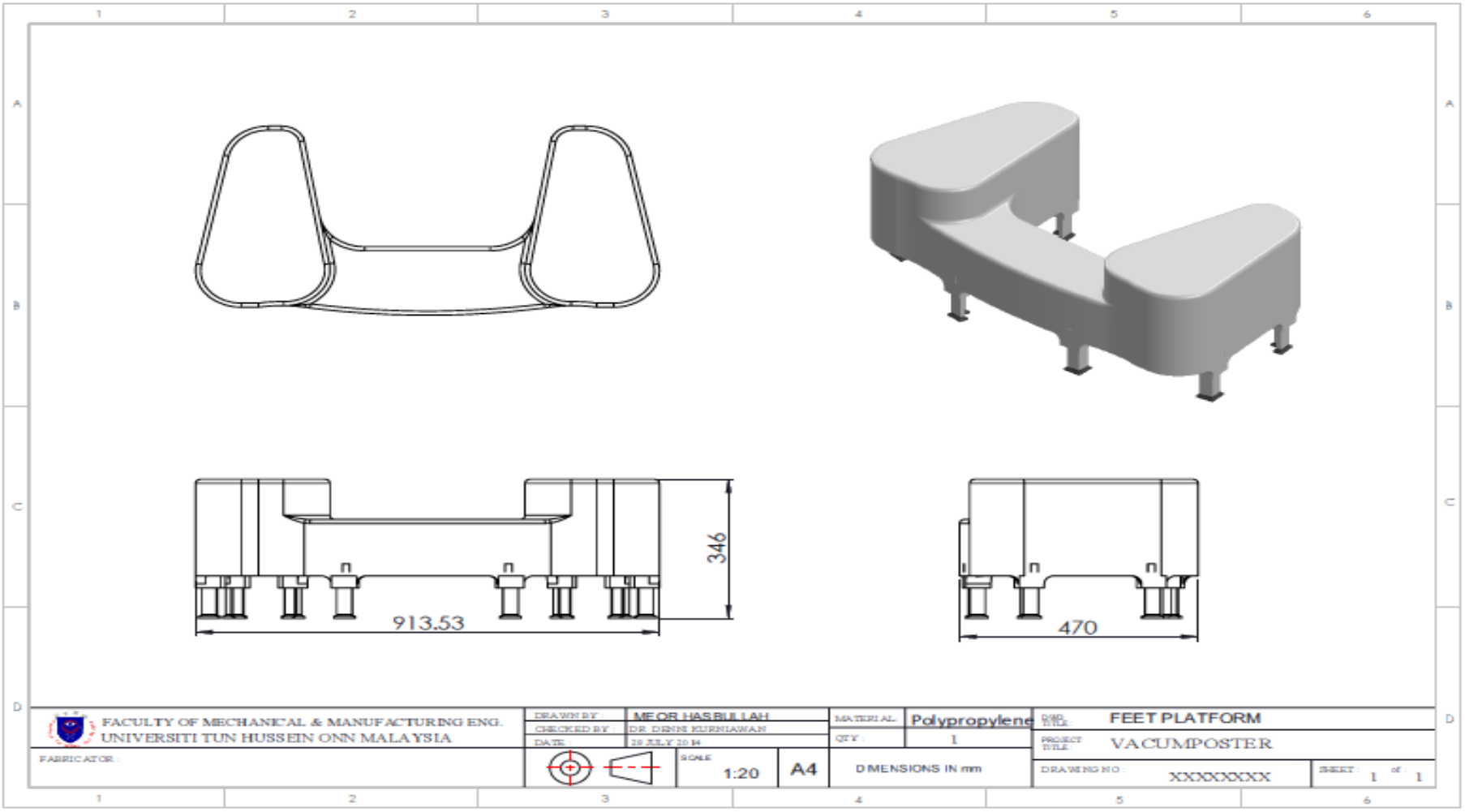

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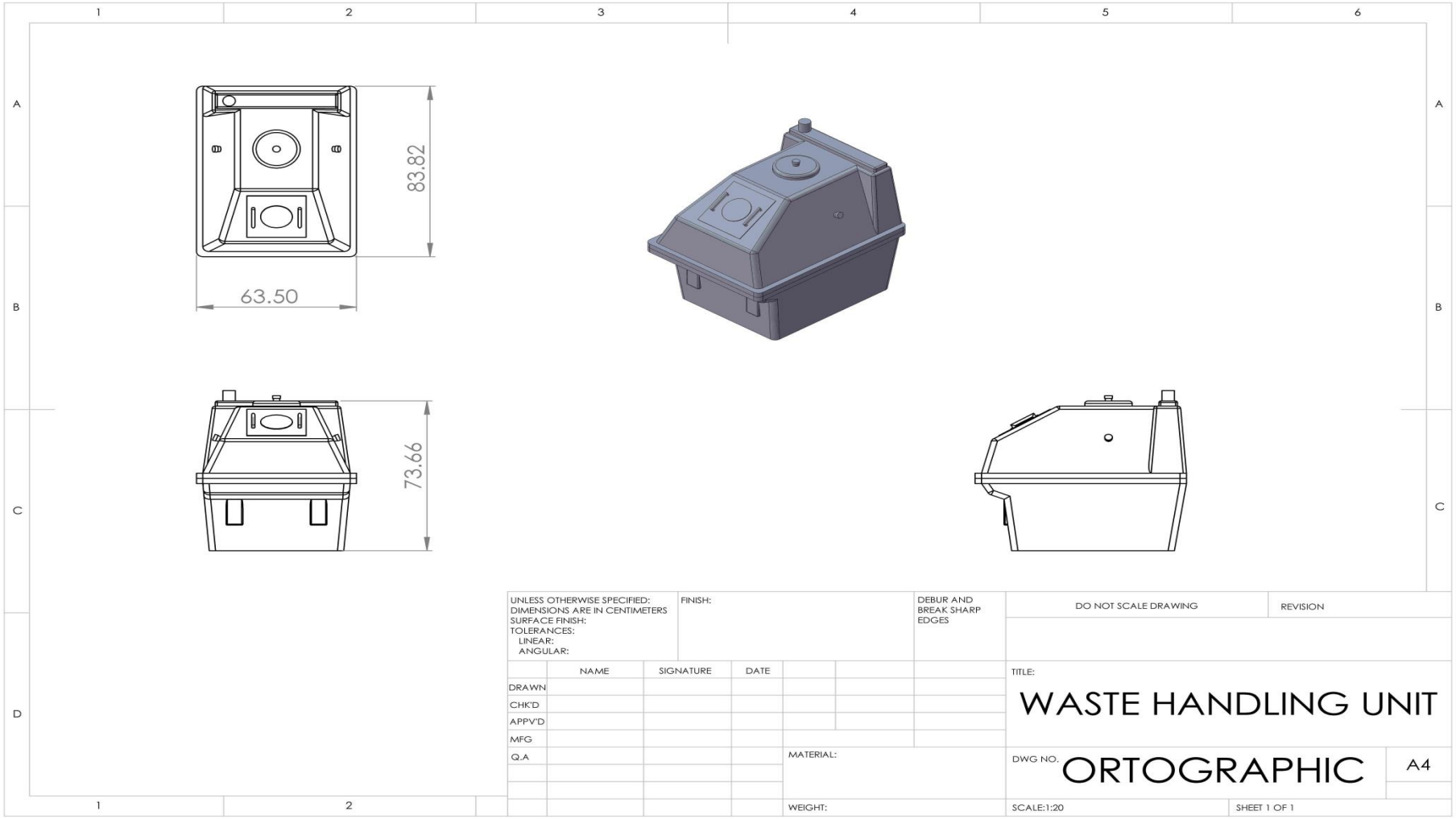

**DIMENSION IN CENTIMETER (CM)