ISSN 1755-1307

IOP Conference Series

Earth and Environmental Science

1st Workshop on Metrology for Agriculture and Forestry (METROAGRIFOR)

275

VOLUME 275 – 2019

3–2 October 2018
Ancona, Italy

EDITOR
Enrico Pietro Tomasini

The open access journal for conference proceedings

iopscience.org/jpcs

IOP Publishing

PAPER • OPEN ACCESS

Preface

To cite this article: 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **419** 011001

Dear participants,

It is my great pleasure to welcome you in the ICCEE 2019 at The Patra Hotel, Kuta, Bali, Indonesia. I would like to express my appreciation to Director General of Construction Services Development, Ministry of Public Works and Housing, Indonesia as partner. Also to all co-organizers, Kyushu University (Japan), Monash University (Malaysia), Seoul National University (Korea), Universitas Bosowa, Universitas Udayana, Universitas Kristen Indonesia Paulus Makassar, and Universitas Haluoleo. Also to the all the third parties, Japan International Cooperation Agency (JICA), Center of Technology (CoT) Faculty of Engineering Universitas Hasanuddin, PT. Pelindo IV Makassar, PT. MRT Jakarta, PT. Nindya Karya, PT. Bumi Karsa, PT. Wika Beton, PTV Group, and PT. Karya Rezeki Panca Mulia, and PT. Amalia Jaya Pratama, who provide financial support for us, to Construction Services Development Board of South Sulawesi (LPJK SulSel), Inter-University Transportation Studies Forum (FSTPT), Indonesia Transportation Society (MTI), The Institution of Engineers Indonesia, Indonesian Society of Civil and Structural Engineers, HPJI, IAPI, as supporting institutions, and to all the reviewers who have worked on their best helping us to sort hundreds of papers from around the world.

The aim of the conference is to promote scientific advancement, technological progress, information exchange, and cooperation among engineers and researchers in civil and environmental studies. The conference was first held in Makassar, Indonesia in 2010 by the name of Makassar International Conference in Civil Engineering (MICCE 2010) followed by the second conference in 2015 (MICCE 2015). To reflect a broader scope, the conference was renamed to International Conference on Civil and Environmental Engineering (ICCEE)

ICCEE 2019 is held by the Department of Civil Engineering and Department of Environmental Engineering, Faculty of Engineering, Universitas Hasanuddin, Makassar, Indonesia. We received 185 technical papers from various country and will be published in IOP Publishing which is indexed by Scopus. We really hope the 3rd ICCEE 2019 under the theme "Toward Sustainable Green Infrastructure Development in Industrial Revolution 4.0 Era" will provide us a valuable opportunity to share knowledge and experiences. Thank you.

Dr. Eng. Bambang Bakri, M.Eng.
Chair

Table of contents

Volume 419

2020

Previous issue Next issue

The 3rd International Conference on Civil and Environmental Engineering (ICCEE 2019)
29–30 August 2019, Bali, Indonesia

Published online: 08 February 2020

Open all abstracts

Published online: 8 February 2020 Preface

Papers

Infrastructure Development

N C Yee, A Johan, A E Kajuputra and L A Pangestu

+ Open abstract View article PDF

OPEN ACCESS 012004

Individuals' activity space in Seri Iskandar Malaysia

M A Z Khalif and D B E Dharmowijoyo

+ Open abstract View article PDF

OPEN ACCESS 012005

Lock-brick system technology is an ecological building material innovation

C L Susilawati, P K Yulius Suni and E Tjandra

+ Open abstract View article PDF

OPEN ACCESS 012006

Numerical analysis of water temperature difference on baroclinic flow in the region of freshwater influence (ROFI)

A N Arifin, S Yano and A T Lando

+ Open abstract View article PDF

OPEN ACCESS 012007

Provision of community based clean water in Tonggo village, Nangaroro District, Nagekeo Regency

Y Meo and I W Tyas

+ Open abstract View article PDF

OPEN ACCESS 012008

The flatness levels of flexible road based on roadroid software in Perintis Kemerdekaan Street Makassar

M Lukman, H Halim and Z Saing

+ Open abstract View article PDF

OPEN ACCESS 012009

The role of *the Titian* path as accessibility in the marginal housing on the water at Kampung Karabba and Marbor, Buloa-Tallo

N Amri, I Asmal and S Amin

+ Open abstract View article PDF

OPEN ACCESS 012011

Assessment of tsunami risk to offshore platforms in Indonesia archipelago

A Y Baeda and G P Carayannis

+ Open abstract View article PDF

+ Open abstract View article PDF

OPEN ACCESS 012048

Effect of portland composite cement and buton granular asphalt on indirect tensile strength of emulsified asphalt cold mix using limestone aggregate

L One, M W Tjaronge, R Irmawaty and M Hustim

+ Open abstract View article PDF

OPEN ACCESS 012049

Effect of working method on the strength reduction of reinforced concrete beams

Fakhruddin, K Umam and R Djamaluddin

+ Open abstract View article PDF

OPEN ACCESS 012050

Effect steel reinforcement ratio on the behavior of RC beam without concrete at tension zone using truss-system reinforcement

A Amir, R Djamaluddin, R Irmawati and A A Amiruddin

+ Open abstract View article PDF

OPEN ACCESS 012051

Effects of abaca fiber additives for cold emulsion asphalt mixture

BK Manginsihi, M W Tjaronge, AB Muhiddin and T Harianto

+ Open abstract View article PDF

OPEN ACCESS 012052

Experimental evaluation on early age temperature variation of spill way containing Portland composite cement

Anshar, M W Tjaronge, R Djamaluddin and A A Amiruddin

+ Open abstract View article PDF

OPEN ACCESS 012053

Failure mode of truss system concrete beams strengthened with tensile reinforcement

A Amir, R Djamaluddin, R Irmawaty, A A Amiruddin and Fakhruddin

+ Open abstract View article PDF

OPEN ACCESS 012054

Feasibility of crumb rubber as fine aggregate in concrete

R Irmawaty, N M Noor and A A Muhaimin

+ Open abstract View article PDF

OPEN ACCESS

+ Open abstract View article PDF

OPEN ACCESS 012063

The effect of additional sugar palm fibres on the durability of mixed Laston AC-WC

S A Datu, R Rachman and M Selintung

+ Open abstract View article PDF

OPEN ACCESS 012064

The effect of clamshells partial substitution of coarse aggregates on the mechanical properties of shellfish concrete (*Berang*)

E Ngii, W Mustika, A S Sukri, R Balaka, R Sriyani and L Welendo

+ Open abstract View article PDF

OPEN ACCESS 012065

The effect of dogbones on the behaviour of a castellated steel beam under cyclic loads

R Firman, M Amin, H Parung, R Irmawaty and A A Amiruddin

+ Open abstract View article PDF

OPEN ACCESS 012066

The effect of the shape and size of HDPE plastic admixtures on to K125 concrete

Tamrin, M Jamal and P Ramadhani

+ Open abstract View article PDF

OPEN ACCESS 012067

The processing, properties and optimum mix of fly ash based - self compacting geopolymer concrete

C Sondakh and S Gumalang

+ Open abstract View article PDF

OPEN ACCESS 012068

Utilization of tire chips as a substitute for coarse aggregate in concrete

H Parung, R Irmawaty and D M Wijaya

+ Open abstract View article PDF

OPEN ACCESS 012069

Vibration optimization of laminated composite plates using genetic algorithm with various discrete fiber angles

M Innami, Y Narita, K Sasaki and S Honda

+ Open abstract View article PDF

OPEN ACCESS

S F Badaron, S Lawalenna, T Harianto and D Rahman

+ Open abstract View article PDF

OPEN ACCESS 012085

Study of traditional market waste bioremediation in lowland city as materials for making compost and prospects of development

I R Rahim, T Harianto and M Ihsan

+ Open abstract View article PDF

OPEN ACCESS 012086

The infiltration capacity of eco-concrete paving on different block shapes

J Rangkang, L Samang, S Adisasmita and M Hustim

+ Open abstract View article PDF

Transportation and Urban Engineering

OPEN ACCESS 012087

An analysis of the travel time in the Unhas lecturer housing of Makassar city

R Rachman, R Mangontan and A Toding

+ Open abstract View article PDF

OPEN ACCESS 012088

Analysis of correlation between urban heat islands (UHI) with land-use using sentinel 2 time-series image in Makassar city

S Rauf, M M Pasra and Yuliani

+ Open abstract View article PDF

OPEN ACCESS 012089

Characteristics of marshall additional hot rolled sheet base rattan fiber

Alpius

+ Open abstract View article PDF

OPEN ACCESS 012090

Delay distribution estimation at a signalized intersection

Susilawati, M I Ramli and H Yatmar

+ Open abstract View article PDF

OPEN ACCESS 012091

Design principle of evacuation route for the pedestrian during a flood event in Borgo village

F P Makalew and D J F Mandang

+ Open abstract View article PDF

OPEN ACCESS 012092

Developing a direct gravity trip distribution model for air passenger demand

H Suprayitno

+ Open abstract View article PDF

OPEN ACCESS 012093

Efficiency of simple curb inlet design in Malaysia

Z Mustaffa, S M P Meganathan and A B K Zaman

+ Open abstract View article PDF

OPEN ACCESS 012094

Friendliness of route along the home-school journey for less privileged children in old city zone of Makassar

A M Asrun, I Said and N Rusli

+ Open abstract View article PDF

OPEN ACCESS 012095

Ground deformation analysis on road infrastructure in north buton Indonesia using interferometric synthetic aperture radar (Insar)

L M G Jaya, J Safani, A Okto, M Hasbi and A Kadir

+ Open abstract View article PDF

OPEN ACCESS 012096

Influence of elementary students walking speed to children pedestrian pathway planning

F P Makalew, S A Adisasmita, S Wunas and S H Aly

+ Open abstract View article PDF

OPEN ACCESS 012097

Model influence means operational performance on the port of Jayapura

Bahtiar, S A Adjisasmita, M I Ramli and M Pasra

+ Open abstract View article PDF

OPEN ACCESS 012098

Model of logistic transport distribution in the urban area

A A Putra, L O M Magribi, T Sharly, E Ngii, A S Sukri, A S Sukri, R Balaka, T Azikin, Lawalendo, R Sriyani *et al*

+ Open abstract View article PDF

construction

N Azizah, M Hustim and M Pasra

+ Open abstract View article PDF

OPEN ACCESS 012107

Walkability index of real estate housing in Makassar

M Arifin, A R Rasyid and W W Osman

+ Open abstract View article PDF

Water Resources Engineering

OPEN ACCESS 012108

Effect of velocity flow patterns on viscosity in Saddang River

M Hasbi, M S Pallu, R Lopa, M P Hatta and Z Zetiawan

+ Open abstract View article PDF

OPEN ACCESS 012109

Effect of the slope of flume bed to the debris potential flow

F Petrus, M S Pallu, M A Thaha and F Maricar

+ Open abstract View article PDF

OPEN ACCESS 012110

A flume experiment study of energy lose at downstream of a sluice gate

F Maricar, M F Maricar and S G Sasmito

+ Open abstract View article PDF

OPEN ACCESS 012111

A Study on-resistance characteristics and turbulent structure properties of hyper-concentrated sediment-laden flow

L A Hendratta, Sukarno and T Ohmoto

+ Open abstract View article PDF

OPEN ACCESS 012112

An experimental study of clay soils for preliminary data for scour model in open channels

A A Latif, M S Pallu, F Maricar and M P Hatta

+ Open abstract View article PDF

OPEN ACCESS 012113

Coastal morphodynamic and assessments of coastal vulnerability index in Parepare bay

H Sirajuddin and B Rivaldi

+ Open abstract View article PDF

OPEN ACCESS 012114

Determining water rate of the HIPPAM system

B Bakri, M Selintung, F Usman, M Ihsan, Y Arai and N A P Mangarengi

+ Open abstract View article PDF

OPEN ACCESS 012115

Development of flood forecasting model and warning systems at Way Ruhu – Ambon

M Marasabessy, M S Pallu, R T Lopa and M A Thaha

+ Open abstract View article PDF

OPEN ACCESS 012116

Distribution pattern of water salinity analysis in Jeneberang river estuary using ArcGIS

B Bakri, A Sumakin, Y Widiasari and M Ihsan

+ Open abstract View article PDF

OPEN ACCESS 012117

Effect of wave steepness to relative wave run-up on OWEC breakwater

A I D Puspita, M A Thaha, M S Pallu and F Maricar

+ Open abstract View article PDF

OPEN ACCESS 012118

Estimation of aquifer parameters using pumping tests: case study of hotel Makassar paradise

A Suprapti and S Pongmanda

+ Open abstract View article PDF

OPEN ACCESS 012119

Evaluation on sabo dam construction planning Matakabo River at East Seram island

R Malik, M S Pallu, M A Thaha and M P Hatta

+ Open abstract View article PDF

OPEN ACCESS 012120

Experimental and numerical modeling of sand column applied on recharge reservoir to control seawater intrusion

A Azis, H Yusuf, S Badaruddin, M Iqbal, Z Faisal and H Hasanuddin

+ Open abstract View article PDF

+ Open abstract View article PDF

OPEN ACCESS 012129

Preliminary sediment modeling at the confluence of the Mahakam and Karang Mumus River

A Nur, M P Hatta, M A Thaha and D A Suriamihardja

+ Open abstract View article PDF

OPEN ACCESS 012130

Relevance between filtration rate and filter media thickness in downflow filter systems

Y Adriati, M S Pallu, M Selintung and B Bakri

+ Open abstract View article PDF

OPEN ACCESS 012131

Stability of breakwater armour using rock pockets on transition wave

I Rohani, M A Thaha, M P Hatta and C Paotonan

+ Open abstract View article PDF

OPEN ACCESS 012132

Stratification model of seawater mass structure at the estuaries of Jeneberang River and Tallo River and the influences to current pattern in Makassar coastal areas

R Karamma, M S Pallu, M A Thaha and M P Hatta

+ Open abstract View article PDF

OPEN ACCESS 012133

The construction of Karalloe multipurpose dam for the Kellara technical irrigation development

M Hasbi, Subandi, M Mappanyompa and B Bakri

+ Open abstract View article PDF

OPEN ACCESS 012134

Effect of water discharge variation on water levels and flow characteristics in pipeline networks

R Bachrun, M S Pallu, M A Thaha and B Bakri

+ Open abstract View article PDF

OPEN ACCESS 012135

The effect of wave reflection coefficient to the breaker parameter on OWEC breakwater

A I D Puspita, M S Pallu, M A Thaha and F Maricar

+ Open abstract View article PDF

Construction Project Management

Practical production of lightweight concrete floor tiles

A Faslih, I Kadir and M Z Umar

+ Open abstract View article PDF

OPEN ACCESS 012151

Structural ductility of RBS on castellated beam subjected to cyclic loading

N H Aswad, H Parung, R Irmawaty, A A Amiruddin and Fakhruddin

+ Open abstract View article PDF

OPEN ACCESS 012152

Study and overview of the occupational health and safety management in the construction industry

R Arifuddin, I R Rahim, E Aprianti and A Radiatullah

+ Open abstract View article PDF

Environmental Engineering

OPEN ACCESS 012153

Air dispersion modelling of gas turbine power plant emissions in Makassar by using AERMOD

R Zakaria, S H Aly and Annisa

+ Open abstract View article PDF

OPEN ACCESS 012154

Analysis of effectiveness aeration time with biofilter and ras combination systems on bulking parameters

I A Mursalim, M S Pallu, M Selintung and I R Rahim

+ Open abstract View article PDF

OPEN ACCESS 012155

Analysis of e-waste components at a computer service center of Makassar City

A T Lando, M A Abdurrahman, A N Arifin and R Utami

+ Open abstract View article PDF

OPEN ACCESS 012156

Analysis of infrastructure needs and operational systems for traditional market solid waste management (A case study on Makassar – Niaga Daya traditional market)

N A P Mangarengi, A Zubair and M A Abdurrahman

+ Open abstract View article PDF

OPEN ACCESS 012

Assessing effects of temporal changes in River water temperature on stratification in

the Ariake Sea

A N Arifin, S Yano and A T Lando

+ Open abstract View article PDF

OPEN ACCESS 012158

Development of eco-friendly paving block incorporating co-burning palm oil-processed tea waste ash

M A Caronge, A T Lando, I Djamaluddin, M W Tjaronge and D Runtulalo

+ Open abstract View article PDF

OPEN ACCESS 012159

Eco-drainage system planning with SWMM model: a case study of Sawah Liat drainage, Kuranji watershed in Padang City, Indonesia

A Junaidi, H Putra, B Istijono, N Nurhamidah and M Utama

+ Open abstract View article PDF

OPEN ACCESS 012160

Effectivity of constructed wetland using *Typha angustifolia* in analyzing the decrease of heavy metal (Fe) in acid mine drainage

A Zubair, N O Abdullah, R Ibrahim and A R D Rachma

+ Open abstract View article PDF

OPEN ACCESS 012161

Effects of change of density stratification due to Isahaya Sea-Dyke on the fate of anoxic water in the Ariake Sea

M Tadokoro, S Yano, Q Peizhi and L Orrheim

+ Open abstract View article PDF

OPEN ACCESS 012162

Evaluation of the effectiveness of wastewater treatment plant for super-intensive shrimp farms (A case study on Punaga Village, Takalar)

N A P Mangarengi, M Selintung, A Zubair and F Ahmad

+ Open abstract View article PDF

OPEN ACCESS 012163

Investigation of CO emissions on alternative car free day roads in the city of Makassar

R Zakaria, M Pasra and Herliani

+ Open abstract View article PDF

OPEN ACCESS 012164

Investigation of CO emissions on school areas based on Caline-4

S H Aly, A A Amiruddin and D Y Winardhy

+ Open abstract View article PDF

OPEN ACCESS 012165

Laboratory study on the effect of leachate type to swelling behavior of bentonite

K Sari, I Ridwan and A T Lando

+ Open abstract View article PDF

OPEN ACCESS 012166

Performance evaluation of sewage treatment plants in the building of Gowa Engineering campus

N A P Mangarengi, M Selintung, A Zubair and N Mujahid

+ Open abstract View article PDF

OPEN ACCESS 012167

Study of correlation between noise and disturbance to workers in the Soekarno Hatta Area of Makassar

M Hustim, S A Adisasmita and R Alifiadi

+ Open abstract View article PDF

OPEN ACCESS 012168

Study of noise level at roundabouts in Maminasata area

M Hustim, M I Ramli and M F Nabila

+ Open abstract View article PDF

OPEN ACCESS 012169

The capability of green open space in absorbing carbon monoxide and carbon dioxide emissions in Balai Kota Makassar

S H Aly, R Zakaria and C F Kondorura

+ Open abstract View article PDF

OPEN ACCESS 012170

The influence of solution pH on the absorption of heavy metals Cr (VI) by *Saccharomyces cerevisiae* biomass

R Ibrahim, M N Djide and C Lapik

+ Open abstract View article PDF

OPEN ACCESS 012171

The reduction of heavy metals Cd and Cr levels in wastewater using bagasse charcoal as an adsorbent

M Selintung, N A P Mangarengi, A Zubair and Sulviani

+ Open abstract View article PDF

OPEN ACCESS 012172

Utilization of reject material in raw grinding mill unit as industrial wastewater adsorbent

H Husain and N O Abdullah

+ Open abstract View article PDF

JOURNAL LINKS

Journal home

Journal scope

Information for organizers

Information for authors

Contact us

Reprint services from Curran Associates

PAPER • OPEN ACCESS

Experimental and numerical modeling of sand column applied on recharge reservoir to control seawater intrusion

To cite this article: A Azis *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **419** 012120

Experimental and numerical modeling of sand column applied on recharge reservoir to control seawater intrusion

A Azis[1], H Yusuf[1], S Badaruddin[1], M Iqbal[1], Z Faisal[1] and H Hasanuddin[1]

[1]Civil Engineering Department, State Polytechnic of Ujung Pandang, Makassar, Indonesia

Email: akhmad_azis@yahoo.com

Abstract. Excessive groundwater exploitation may lead to groundwater depletion, causing groundwater level at the inland lower than sea level and result in seawater intrusion (SWI) in a coastal aquifer. To control the occurrence of SWI, an alternative solution is to increase the replenishment of groundwater using a recharge reservoir. If a recharge reservoir is built in a region with soil hydraulic conductivity below 10-5 cm/s (semi impermeable), then a sand column is usually proposed, put on the bottom of the recharge basin and directly connected to the aquifer layer. The purpose of this study is to analyze the effectiveness of the sand column's application in the recharge reservoir to control SWI. This research is an experimental study that combines physical and numerical modeling of the recharge basin with sand columns under a laboratory scale. The results of this research are beneficial for field applications because the process that occurs in the recharge reservoir can be determined prior to the real construction in the field. The results of the research are also useful to investigate whether the recharge reservoir is effective or not as a buffer of SWI in coastal aquifers. The expected result is that by using sand columns in the recharge basin, seawater intrusion can be controlled. It is hypothesized that the higher the number of sand column density and water level on the reservoir, the farther the freshwater saltwater interface is pushed toward the sea.

1. Introduction

In some big cities, groundwater extraction is so intensive. Many industries, residential housings, and hotels utilize production well of up to 20 wells with a capacity of more than 8,000 m3 per day, resulting in a decrease of groundwater level that will impact in replacement of freshwater by seawater in coastal aquifers. This process is called as seawater intrusion (SWI). The intensity of groundwater extraction is deeply related to the amount of freshwater replaced by saline water inside aquifer [1]. If SWI has reached the production wells, then the freshwater in the wells will be contaminated and can no longer be used for daily usage. To overcome the problem, natural and artificial recharge by building absorption wells, bio pore holes or other absorption techniques have been done but the results sometimes are not optimal to maintain the minimal groundwater level required to control SWI. The recharge reservoir method that is currently developed in Indonesia can be a solution. However, the problem is that if the recharge reservoir is built in a region where its soil permeability is less than 10^{-5} cm/s (semi impermeable), then a sand column that placed on the bottom of the recharge basin and directly connected to the aquifer layer is required. For this reason, there will be an analysis to investigate the effectiveness of sand columns in the recharge basin as a buffer of SWI. Here, an

experimental study is conducted by combining physical and numerical modeling under the scale of the laboratory.

2. Literature review

2.1. Seawater intrusion

It is understandable that the role of groundwater as a natural resource besides surface water for clean water supply is increasing since groundwater has several advantages over surface water [1]. For example, more hygiene because it has undergone a natural filtration process, its quality is relatively fixed, its investment is relatively low, and groundwater can be found easily. Communities, both individuals and groups need water for everyday purposes and for other needs. Water for drinking is a top priority compared to other needs. This means that the function of water as drinking water should be supported in order to meet the quality and quantity required [2]. Therefore, groundwater use should consider the balance and sustainability principles by filling more water into the soil, either by natural or artificial means.

The coastal zone as shown in figure 1, is territories that form low lying topography and morphology seen in the form of the coastal plain. Geologically, the constituent rocks are generally alluvial deposits consisting of clays, sand, and gravel resulting from the transport and erosion of rocks in the upper reaches of the river. Generally, the rocks in the plains are loose, so the potential of groundwater is quite good. The main problem in the coastal zone is the diversity of the aquifer system, positioning, and dispersal of seawater intrusion which is mostly caused by excessive groundwater extraction for the needs of fishermen and industry.

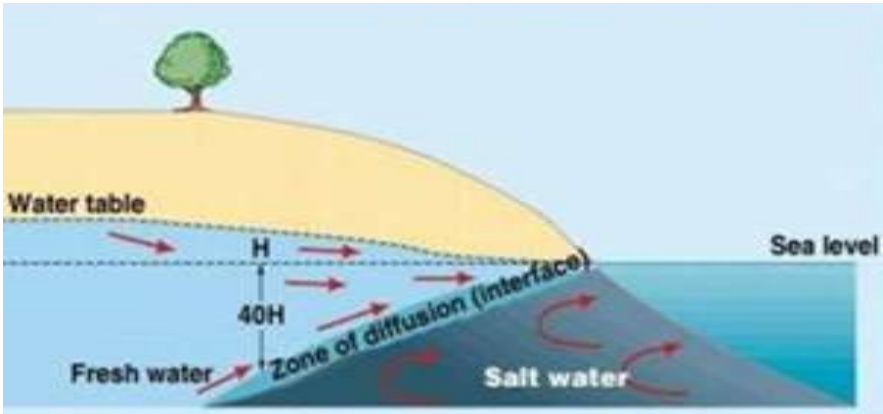

Figure 1. The cross-section of freshwater and seawater interface in coastal aquifers.

2.2. Positioning

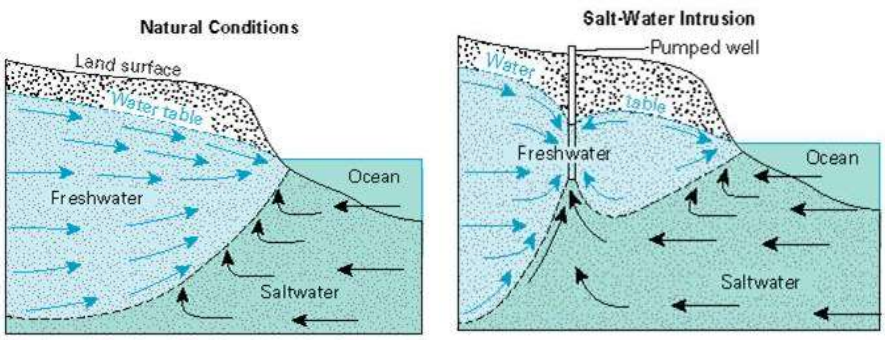

Figure 2. Interface conditions that are natural and already experienced SWI.

Naturally, seawater cannot enter far into the mainland because freshwater in the aquifer has a piezometric that is higher than seawater so that the interface is formed as the boundary between freshwater and seawater. It is the state of equilibrium between seawater and freshwater in the aquifer.

Seawater goes into the aquifer system passes through two systems, namely SWI and up coning as shown in figure 2. Under natural conditions, groundwater from the land will flow continuously into the sea and this called freshwater discharge. Saltwater density is slightly larger than freshwater density, thus seawater will push freshwater in the aquifer more inland. Because water pressure in the aquifer is higher than sea level, the pressure can be neutralized and the freshwater discharges to the sea, creating a balance between seawater and freshwater [3]. Seawater intrusion occurs when this balance is disrupted. Activities that cause seawater intrusion include groundwater extraction through excessive pumping, coastal characteristics and constituent rocks, groundwater head, and groundwater fluctuations in coastal areas [4,5]. According to Ghyben - Herzberg concept, saltwater is found at a depth of 40 times the freshwater head above sea level. This phenomenon is caused due to differences in gravity between seawater (1025 g/cm3) and freshwater type (1000 g/cm3). So, we get the value of z= 40 hf. where: hf= groundwater head above sea level (m); z= interface depth under sea level (m); ρs= density of seawater (g/cm3); ρf= density freshwater (g/cm3). There are several ways to control SWI, such as;

2.2.1. Changing the pumping pattern

Moving the pumping location from the coast to the upstream will increase the slope of the hydraulic slope towards the sea, resulting in water pressure in the aquifer will grow as shown in figure 3. The freshwater level in the aquifer is raised by artificial recharge. For unconfined aquifers, it can be done by spreading water on the surface of the soil, whereas in the confines aquifer, it can be charged directly into the aquifer. In this research, the recharging water will be filling into the aquifer by placing the sand column in the recharge basin. This method has never been done either in the form of research in laboratory or application in the field a table is divided into parts these should be labeled (a), (b), (c), etc but there should only be one caption for the whole table, not separate ones for each part.

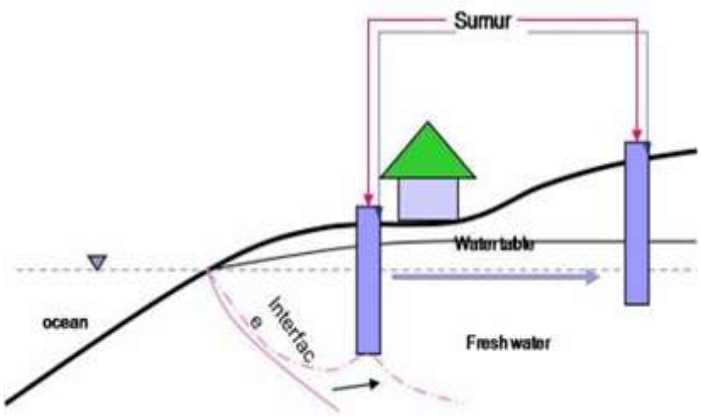

Figure 3. Changing the Pumping Pattern.

2.2.2. Artificial groundwater recharge

Freshwater level in the aquifer is raised by artificial recharge as shown in the figure 4. For unconfined aquifers, it can be done by spreading water on the surface of the soil, whereas in the confines aquifer, it can be charged directly into the aquifer. In this research, the recharging water will be filling into the aquifer by placing the sand column in the recharge basin. This method has never been done either in the form of research in laboratory or application in the field.

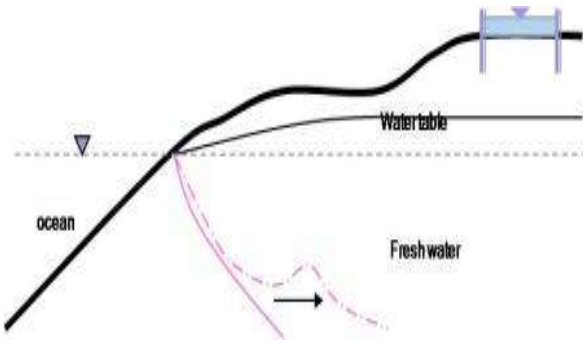

Figure 4. Artificial groundwater recharge

2.2.3. Extraction barrier

Extraction barriers as shown in figure 5 can be made by continuously pumping saltwater at wells located near the coastline. This pumping will lead to the occurrence of saltwater basin and freshwater will flow into the basin. As a result, there is a seawater wedge to the mainland.

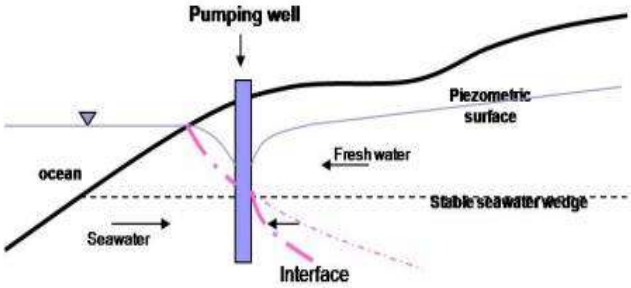

Figure 5. Extraction Barrier.

2.2.4. Injection barrier

Injection barriers as shown in figure 6 can be made by filling freshwater at wells located near the shoreline. Filling the water will raise the water table in the well and will serve as a barrier to the entry of seawater to the mainland.

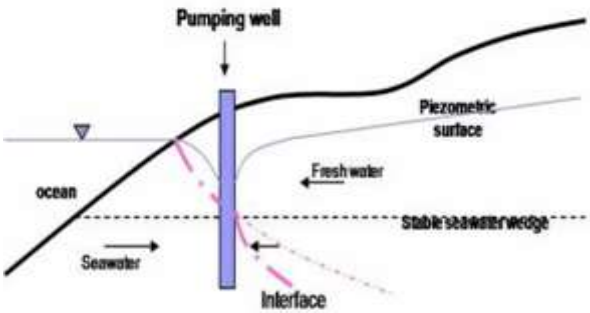

Figure 6. Injection Barrier.

2.2.5. Subsurface barrier

Barriers underground as a barrier between saltwater and freshwater as shown in figure 7 can be in the form of the dam, which is made from clay, concrete, bentonite or asphalt.

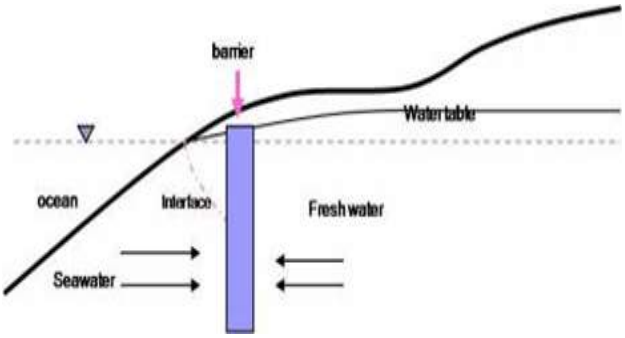

Figure 7. Subsurface Barrier.

2.3. The model of recharge basin with sand columns

2.3.1 More complex tables

One form of artificial recharge is a recharge basin that has a primary function as a water absorption medium to easily and quickly enter the aquifer layer. This reservoir model is suitable for land with shallow groundwater and wide land available. The basic philosophy in the development of a catchment basin is how to minimize surface runoff and to improve soil's ability to absorb surface runoff. The creation of a catchment basin is different from the usual reservoir making. The recharge basin is made with a reservoir base connected directly with the aquifer layer. The recharge reservoir is essentially can be categorized as a single reservoir (single-purpose) which serves as a flood control system with employment increasing aquifer function optimization, which increases the ability of the shelf water in the aquifer layer.

The functions of recharge reservoir are:

- To optimize the aquifer function so that it can increase the shelf life of the water in the aquifer
- It can serve as flood control in the downstream area or runoff.
- As a reserve of water for the needs in the dry season.

The results of the study of the Ministry of Research and Technology in Indonesia which has been done since 2003 and it is known that the application of the technology of the infiltration reservoir is able to overcome the flood and drought that hit Indonesia every year. The rate of infiltration (infiltration rate) in the reservoir is quite high.

2.3.2 Physical models of the sand column

The sand column serves as a medium to absorb the water of the recharge basin into the aquifer layer. The sand column is made using a drill on a clay layer that has a small permeability and restocked with graded coarse sand. The sand must be watered without carrying fine soil particles.

Water from surface water is stored in reservoirs with a certain height. Then the water is streamed through sand columns in the hope that sand that has a value of the coefficient of large permeability, can accelerate and increase the occurrence of recharge, as well as filtration for water into the aquifer layer is in a clean state.

3. Methods of research

3.1. The technique of collecting data from the experiment model

This study uses a square test tube consisting of three spaces namely space A contains seawater that has been given a coloring substance with a size of 30 x 10 x 100 cm, space B contains sand with size 40 x 10 x 100 cm and space C which is recharge reservoirs using sand columns with size 80 x 10 x 100 cm Land that has been known to type and meet the permeability requirements, put into the tub, then made

the sand column. On the surface of the basin are given debit entries freshwater (Q1) and the flow of seawater (Q2) each with a height of a particular water, at the time the land has undergone a water-saturated (saturated), seawater by substances dyes, then performed the measurement length of freshwater pushes seawater (L) in room B containing crushed stone each 3 variations for water level in the reservoir of reservoir (H2) of 5; 7.5; 10 cm, sand column height (Z) of 30; 32.5; 35 cm and the number of sand columns (Nc) of 0; 2 and 4 pieces . Sea level (H1) is fixed to 50 cm.

3.2. The technique of collecting data from the numerical model

This study uses the numerical modeling of SEAWAT to investigate the effectiveness of sand columns on the recharge reservoir to control SWI under laboratory scale [5,6]. The domain of the numerical model, namely in the form of two models dimensional rectangular size with assumption sea in the left and reservoir recharge in the right of the model. Land of known type and eligible permeability, as aquitard layer, then made as a sand column. On the surface of the basin are given a debit entry (Q1) and the seawater flow rate (Q2) each with a certain water level. At the time the soil has become water-saturated and happen equilibrium between seawater and freshwater in the aquifer system, further measured the length of freshwater pushing the seawater (L) in the aquifer of each 3 variations for the water level in the infiltration reservoir (H1) of 5; 7.5; 10 cm, sand column height (Z) of 30; 32.5; 35 cm and the number of sand columns (Nc) of 0; 2 and 4 pieces.

4. Expected results

1. From numerical modeling results, it expected that the effectiveness of sand column sand controlling SWI can be determined.
2. The number of sand columns will increase the freshwater pressure in the aquifer and will reduce the SWI.
3. Results of numerical modeling can be beneficial to explore the role of water level above the reservoir and the thickness of the impermeable layer in influencing SWI. This is supported by the results of previous studies by Azis (2014), which states that each additional column of sand and water level of reservoirs as well as lower impermeable layer will increase the discharge of groundwater recharge into the aquifer.
4. The results obtained from the experimental and numerical modeling is expected the same with a maximum deviation of 20%.

Acknowledgments

We sincerely thank especially to Head of Civil Engineering Department, State Polytechnic of Ujung Pandang for supporting and providing an opportunity to conduct this research.

References

[1] Seutloali KE, Beckedahl HR 2015 Understanding the factors influencing rill erosion on roadcuts in the southeastern region of South Africa *London: Solid Earth* **6** (2) 633–41

[2] Aeschbach-Hertig W, Gleeson T 2012 Regional strategies for the accelerating global problem of groundwater depletion *Moscow: Nat Geosci* **5** (12) 853–61

[3] Luyun R, Momii K and Nakagawa K 2011 Effects of Recharge Wells and Flow Barriers *Amsterdam: Ground Water* **2** (49) 239–249

[4] Werner AD, Bakker M, Post VEA, Vandenbohede A, Lu C, Ataie-Ashtiani B, et al 2013 Seawater intrusion processes, investigation, and management: Recent advances and future challenges *Amsterdam: Adv Water Resources* 51 3–26

[5] Badruddin S, Werner AD, and Morgan L K 2017 Characteristics of Active seawater intrusion *London: Journal of Hydrology* 632-647

[6] Qahman K and Larabi A 2004 Numerical modeling of seawater intrusion in Khan-Younis area of the Gaza Strip Aquifer, Palestine *London: Developments in Water Science* **2** (55) 1629–1641