

Water Supply Management System And Social Capital

Volume 3



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**Water Supply
Management System
And Social Capital
Volume 3**



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Water Supply Management System and Social Capital Vol. 3

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preface

This book is a third volume from the series of international conference initiated by the Kyoto University GCOE program "Global Center for Education and Research on Human Security Engineering for Asian Megacities," which launches a network of global academic research partnerships among Asian countries since 2008. The book contains 31 selected paper of "The Third International Conference of Water Supply Management System and Social Capital " and funded by the Kyoto University GCOE program.

The third international conference on Water Supply Management System and Social Capital was held on March 21-22, 2011 at Widyaloka Building of Brawijaya University, Malang, Indonesia. The conference presented 42 selected papers and attended by 250 participants covering scholars, practitioners, undergraduate and graduate students from Indonesia, Singapore, Japan, Korea and India involved in the warm sharing knowledge and experience. The purpose of the book is to share theoretical and practical knowledge of water supply management system and social capital by providing a variety of issues of water supply and management in developing countries, as many cases exemplified in this book occur in Indonesia and other developing countries. The book is divided into 6 parts, covering 1) collective action and water governance issues; 2) social and management issues in water provision and distribution; 3) other sustainability issues of water supply and services, 4) methods and measures for water demand and supply, 5) regulations and policies for water use, and 6) techniques for monitoring water qualities.

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Content

Preface	i
List of Figures	xi
List of Tables	xvii
Chapter 1 – Water Supply Management System and Social Capital.....	1
1.1 Introduction.....	1
1.2 Organization Of The Book.....	2
Part 1 Collective Action and Water Governance Issues	
Chapter 2 – Foundations of Collective Action: Towards A General Theory	9
2.1 Collective Action Problem (CAP)	11
2.2 Traditional Approaches In Modeling Collective Action	13
2.3 A Critique Of The Pd Perspective	15
2.4 A Critique Of The 'Logic' Perspectives	16
2.5 Collective Action In Marxian Framework	20
2.5 Foundations Of Collective Action: A General Theory	21
2.6 Corruption And Collective Action: Applying The Theory	26
2.7 Concluding Remarks.....	27
Chapter 3 – Collective Action and Water Right.....	33
3.1 Introduction.....	33
3.2 Basic Idea	34
3.3 Water Rights	37
3.4 Rights Reallocation.....	41
3.5 Participatory Approach.....	42
3.6 Conclusion	44
Chapter 4 – Water Governance in Indonesia: From Indigenous to Post Colonial Technology	49
4.1 Introduction.....	49
4.2 Review On Water Governance Issues	50
4.3 Cultural Theory	54
4.4 Indonesian History Of Water Governance	62
4.5 Analysis Of The Past And Present Water Governance	75
4.6 Conclusion	80

Part 2 Social And Management Issues in Water Provision and Distribution

Chapter 5 – The Role of Geospatial Data For Supporting Water Resources Management And Water Balanced Mapping.....89

5.1 Background 89

5.2 Issues And The Role Of Geospatial Data In Water Supply Management. 90

5.3 Framework Of Better Water Supply Management..... 93

5.4 Water Balanced Mapping..... 94

5.5 Conclusion 95

Chapter 6 – Participatory Approach to Community Based Water Supply System.....97

6.1 Introduction..... 97

6.2 An Empirical Research..... 98

6.3 Model and Estimation Method..... 102

6.4 Results and Discussions 106

6.5 Conclusion 111

Chapter 7 – Structure of Social Network: Centrality and Cohesion A Case of Access to Clean Water.....113

7.1 Introduction..... 113

7.2 Social Capital In Collective Action 114

7.3 Social Network Analysis (SNA) 115

7.4 An Empirical Case 119

7.5 Conclusion 131

Chapter 8 – Community-Based Social Marketing as a New Perspective in Water Management133

8.1 Introduction..... 133

8.2 Social Marketing And Community-Based Social Marketing 134

8.3 The Campaign Of “Molto Ultra Once Rinse Movement” (Gerakan Sekali Bilas Molto Ultra) 138

8.4 Spatial Community-Based Social Marketing..... 144

8.5 Conclusion 147

Chapter 9 – Sustainability Factors of Community Rural Water Supply (Case: Ciburial Village).....151

9.1 Introduction..... 151

9.2 Factors Influencing Sustainability of Water Supply System 152

9.3. Community Water Supply In Ciburial Village..... 154

9.4 Results and Discussion..... 158

9.5 Conclusion 160

Chapter 10 – Comprehensive Social Participatory Model for Water Springs Conservation Management in Indonesia	163
10.1 Introduction.....	163
10.2 Research Method	165
10.3 The Outcome Of FGD Model	169
10.4. Water Springs Management Planning Treaty And Water Springs User Forums Recommendation.....	177
10.5 Conclusion	179
Chapter 11 – Water Resources Management for Public Health and Local Business in Yogyakarta: Simulation New Low Impact Development Model Based on UU No 32/2009 and PP No 82/2001.....	181
11.1 Introduction.....	181
11.2 Water Resources in The City.....	182
11.3 Water Resources and City Development	183
11.4 Water Resources and Business Activities In Yogyakarta	183
11.5 Water Resources Management In Yogyakarta (Based On UU No 32/2009 And PP No 82/2001).....	184
11.6 Water Resources Monitoring In Yogyakarta: Simulation New Low Impact Development (NLID)-UU No 32/2009 and PP No 82/2001.....	186
11.7 Conclusions	187
Part 3 Other Sustainability Issues of Water Supply and Services	
Chapter 12 – Structurization of Water Supply In Malang City...191	191
12.1. Introduction.....	191
12.2 Research Method	191
12.3 Result and Discussion	192
12.5 Conclusion	202
Chapter 13 – An Overview of Water Supply Provision for the City of Banda Aceh.....	205
13.1 Introduction.....	205
13.2 Theory Consideration	206
13.3 METHODOLOGY	207
13.4 Results and Discussion.....	211
13.5 Conclusion	213
Chapter 14 – Study of Investment on Clean Water Services at Jabodetabek Based on Physical Characteristics ..215	215
14.1 Introduction.....	215

14.2 Methods	216
14.3 Results and Discussion	217
14.4 Conclusion	221
Chapter 15 - Equitable Spatial and Temporal Water Distribution For Sustainable Irrigation Water Management	223
15.1 Introduction.....	223
15.2 The Spatial Model.....	224
15.3 The Temporal Model.....	225
15.4 Discussion.....	226
 Part 4 Methods and Measures For Water Demand And Supply	
Chapter 16 - Climate Change Adaptive Planning and Conflict Resolution Strategy of Krabyakan Spring Utilization.....	229
16.1 Introduction.....	229
16.2 Methods	231
16.3 Result And Discussion	231
Chapter 17 - Historic Preservation Area Riverside Brantas Malang City.....	241
17.1 Introduction.....	241
17.2 Research Method	242
17.3 Results And Discussion	244
17.4 Conclusions and Suggestions	255
Chapter 18 - Spatial Structure of Watershed Riam Kanan as water catchment to Support Raw Water Supply Sustainability for BBM Metropolis	257
18.1 Introduction.....	257
18.2 Method.....	260
18.3 Result and Discussion	261
18.4 Conclusion	266
Chapter 19 - Land Use Management of the Kemoning Watershed in the Sampang Regency	269
19.1 Introduction.....	269
19.2 Kemoning Watershed Boundary Determination	271
19.3 Determination Limits Upper, Middle, Lower Basin Kemoning	272
19.4 Conclusion	280

Chapter 20 – Determination of Basic Water Need Per Liter/ Person/Day in The Consumption of The Type of Real Estate And Village Housing.....	283
20.1 Introduction.....	283
20.2 Review Of Related Literatures.....	284
20.3 Research Method	286
20.4 Data Collection	286
20.5 Results and Discussions	287
20.6 The Recapitulation of Water Need Per Liter/Person/Day for The Type Of Village Housing And Real Estate in Malang City	288
20.7 Conclusions and Suggestions	290
Chapter 21 – Runoff Characteristics of Upper and Lower Parts of Samin Sub Watershed, Solo Watershed....	293
21.1 Introduction.....	293
21.2 Materials And Method	294
21.3 Results and Discussion	295
21.4 Concluding Remarks.....	299
Part 5 Regulations and Policies For Water Use	
Chapter 22 – Freshwater Potential for Drought Mitigation in East Sumba, East Nusa Tenggara, Indonesia	301
22.1 Introduction.....	301
22.2 Freshwater Potential And Challenges In East Sumba.....	302
22.3 Integrated Watershed Management Experiences Throughout The World.....	305
22.4 Success Factors to be Adopted In Integrated Watershed Management in East Sumba	309
22.5 Conclusion	312
Chapter 23 – Women’s Handling for Domestic Water and Wastewater to Preserve Sustainability of Water...315	315
23.1 Introduction.....	315
23.2 Method	316
23.3 Result and Discussion	318
23.4 Conclusion	322
Chapter 24 – Sustainable Water Management in Pontianak City.....	323
24.1 Introduction.....	323
24.2 Water Management Principles	324
24.3 Sustainable Water Management	327
24.4. Concluding Discussion.....	329

Chapter 25 – Policy Studies on The Use of Underground Water Resources in Banjarbaru City	331
25.1 Introduction.....	331
25.2 Method.....	332
25.3 Result and Discussion	333
25.4 Conclusion	337
Chapter 26 – Rethinking the Role of Social Capital on Water Distribution Among the Poor	341
26.1 Water and Society.....	341
26.2 Local Participation for Better - Development	342
26.3 Towards Sustainable and Better Water Supply Management	343
26.4 The Role of Agencies and Networks.....	343
26.5 Conclusion	344
Chapter 27 – Independent and Effective Regulation in Malaysian water Services: a stakeholders' Perspective.....	347
27.1 Introduction.....	347
27.2 Methods	348
27.3 Reform Process.....	348
27.4 Why Is The Current Regulation Not Effective?	348
27.5 The National Water Services Commission – An Answer For Effective Regulation	349
27.6 Results	349
27.7 Discussion and Conclusion	350
Part 6 Techniques For Monitoring Water Qualities	
Chapter 28 – Produced Water Treatment Using Polyamide Thin-Film Composite Reverse Osmosis Membrane.....	353
28.1 Introduction.....	353
28.2 Materials and Methods.....	354
28.3 Results and Discussion.....	355
28.4 Conclusions	362
Chapter 29 – Removal Phenomena of Cation, Anion, Inorganic and Organic Contents on Water Treatment for Preparation of Raw Water for Drinking Water.....	365
29.1 Introduction.....	365
29.2 Theory.....	370
29.3 Removal Phenomena of Water Contaminants in Preparation of Raw Water for Drinking Water	378
29.4 Conclusion	382

Chapter 30 – Analysis of Water Temperature Characteristics as an Indicator for Sustainable Water Management on the River Forested Watershed	385
30.1 Introduction.....	385
30.2 Methods.....	386
30.3 Results and Discussion	387
30.4 Conclusion.....	389
Chapter 31 – The Analysis of Elements in The Radioactive Waste Water by Neutron Activation Analysis Method and Its Recommendation.....	391
31.1 Introduction.....	391
31.2 Theory	393
31.3 Methods	395
31.4 Results and Discussion.....	398
31.5. Conclusions	403
Chapter 32 – The Effect of Water Characteristic on Disinfection Process by Ozone	405
32.1 Introduction.....	405
32.2. Materials and Methods.....	406
32.3 Result and Discussion	407
32.5 Conclusion.....	411
List of Authors.....	413

List of Figures

Figure 3.1	Availability and accessibility.....	34
Figure 4.1	Group-grid typology of cultures (after Douglas, 1974 & Thompson, 1990)	58
Figure 4.2	Remnants of old canal at Plaosan Temple, Central Java from the 9 th CE, used to divert water from a nearby river probably for sacred use (courtesy of Arief, 2009).....	64
Figure 4.3	The old Lengkong Barrage at Mojokerto from the upstream in 1920 (Courtesy: KITLV, Leiden)	70
Figure 4.4	Flood (1869) by Raden Saleh Sjarif Boestaman (1811-1880) one of the best known painter and a pioneer of modern Indonesian art	74
Figure 5.1	The framework of the role of spatial data for water supply management with the social capital approach (modified from Kuschnicg concept).....	93
Figure 6.1	Location of the research area	99
Figure 6.2	HIPPAM's water reservoir, communal hydrant, PDAM's water reservoir, individual well, river	101
Figure 7.1	Map of research area.....	119
Figure 7.2	Residence of the respondents in Toyomarto village	121
Figure 7.3	Residence of the respondents in Candi Renggo village.....	122
Figure 7.4	HIPPAM's water reservoir, communal hydrant, PDAM's water reservoir, individual well, river	123
Figure 7.5	Scatter plot of total respondent (N = 498).....	127
Figure 7.6	Scatter plot of total respondent (N = 220).....	129
Figure 8.1	Community-based social marketing model	136
Figure 8.2	Water distillation in RW 7 Kelurahan Kebayoran Lama Selatan	142
Figure 8.3	Biopori hole in RW 7 Kebayoran Lama Selatan	143
Figure 8.4	Education Level in Kampung Bunderan, Kamal Muara	145
Figure 8.5	The habitation in Kampung Bunderan, Kamal Muara	145

Figure 8.6	The neighborhood of Kelurahan Gondangdia.....	146
Figure 8.7	An extension of community-based social marketing model.....	147
Figure 9.1	Ciburial Village	155
Figure 9.2	Number of Customers of Ciburial System	157
Figure 10.1	Malang Regency as research areas	164
Figure 10.2	Distribution of 34 water springs in Brantas catchment areas in Malang Regency	165
Figure 10.3	Flowchart of water spring conservation management research methodology.....	166
Figure 10.4	Flow diagram of comprehensive public participatory model	168
Figure 10.5	Focus group discussion for water spring conservation	168
Figure 10.6	Water spring conservation zone in Sumberawan Spring	170
Figure 10.7	Conservation action from one of Sumberawan water Spring Users (Indonesian Army).....	171
Figure 10.8	Water spring conservation zone in Sumber Umbulan Water Spring.....	173
Figure 10.9	Tree planting surround Sumber Umbulan Water Spring by local community water spring users	173
Figure 10.10	Water spring conservation zone in Sumber Beling Water Spring.	176
Figure 10.11	Tree planting surround Sumber Beling Water Spring by local community water spring users	176
Figure 11.1	Water resources and business activity in Yogyakarta.....	184
Figure 11.2	The Framework of the application of water resources monitoring in Yogyakarta	185
Figure 11.3	The framework of the application of water resources monitoring in Yogyakarta with new low impact development (NLID) simulation.....	187
Figure 12.1	Variable data research.....	192
Figure 12.2	Research framework analysis.....	193
Figure 12.3	Activities in Malang City Center.....	193
Figure 12.4	Regional water supply without reservoir.....	201

Figure 12.5. Regional water supply system independent	202
Figure 13.1 Water supply distribution systems	207
Figure 13.2 Water supply distribution systems	208
Figure 13.3 Krueng Aceh River Basin	209
Figure 13.4 Banda Aceh City Map	209
Figure 13.5 Prediction curves for water availability	210
Figure 13.6 The proposed water distribution system.....	212
Figure 14.1 PDAM coverage map	217
Figure 14.2 Difference height map.....	218
Figure 14.3 PDAM coverage map based on distance.....	218
Figure 14.4 Flow duration curve at serpong station 1992-2006	219
Figure 14.5 PDAM investment level map	221
Figure 15.1. Relationship between Awr and Yr.....	224
Figure 16.1 Service area of Krabyakan Spring to Welang watershed.	232
Figure 16.2 Pattern of rain fall variability	233
Figure 16.3 Average debit in Welang watershed (m ³ /sec).....	233
Figure 16.4 Land use of Welang watershed area	234
Figure 16.5 Supply demand water balance in Welang watershed	236
Figure 16.6 Transmission pipe from The Krabyakan Spring (Malang Regency) to Sidoarjo Regency	236
Figure 17.1 Boundary of study area.....	243
Figure 17.2 Existing of the study area.....	243
Figure 17.3 Ancient building that became the object of study	244
Figure 17.4 Land use in the study area	245
Figure 17.5 Land use in the study area	245
Figure 17.6 Existing of the building attached to each other.....	246
Figure 17.7 Access to study area	246

Figure 17.8	On street parking system	246
Figure 17.9	One of the buildings are more than 100 years old.....	247
Figure 17.10	Results of measurement of environmental quality.....	251
Figure 17.11	The level of damage of ancient buildings in the study area	252
Figure 17.12	Potentially preserved ancient buildings.....	254
Figure 17.13	Referrals preservation of ancient buildings.....	255
Figure 18.1	HCV assessment process fowchart	260
Figure 18.2	Digital elevation model sub-sub-watershed RiamKanan.....	261
Figure 18.3	Results identification of land cover based on LandsatTMin 2010 ..	262
Figure 18.4	visualization of vegetation condition in riam kanan water catcment around the impoundment based on Ikonos Images (Courtesy to Goggle).....	262
Figure 18.5	Spatial maps in sub-sub-basin Riam Kanan water catchment	263
Figure 18.6	HCV map 4.1. in sub-sub-watershed Riam Kanan water catchment	265
Figure 18.7	HCV map 4.1. in sub-sub-watershed Riam Kanan water catchment	266
Figure 19.1	Flood area in Kemoning River Downner of the 2002	270
Figure 19.2	Watershed delineation process.....	272
Figure 19.3	Segregation of the Kemoning Watershed	274
Figure 19.4	The Flood potency	275
Figure 19.5	Conection between UWA	278
Figure 19.6	Total accumulation fow	278
Figure 19.7	Area infuential Kemoning Watershed	279
Figure 19.8	Land Management Action with its Location	281
Figure 21.1	Tapan and Dumpul sub-sub watershed in Samin sub watershed..	294
Figure 21.2	Rainfall-runoff relationship at Tapan sub-sub watershed 1975- 2009.....	297
Figure 21.3	Rainfall-runoff relationship at Dumpul sub-sub watershed 1975- 2009.....	297

Figure 21.4	Runoff coefficient at Tapan sub-sub watershed	298
Figure 21.5	Runoff coefficient at Tapan sub-sub watershed	298
Figure 21.6	Suspended sediment at Tapan and Dumpul sub watersheds during 1975-2003.....	299
Figure 22.1	Annual rainfall precipitation in East Sumba year 2000-2009, source: BMKG Klas III Mauhau Waingapu (2010)	303
Figure 22.2	Annual rainfall precipitation in East Sumba year 2000-2009, source: BMKG Klas III Mauhau Waingapu (2010)	304
Figure 23.1	Study area	317
Figure 24.1	Water cycle management.....	327
Figure 25.1	Monitor of well drill in the area of Landasan Ulin.....	334
Figure 25.2	Discharge of well of PDAM Intan Banjar at subdistrict Landasan Ulin.....	334
Figure 25.3	Map of land use along the location of wells drilled PDAM Intan Banjar	338
Figure 25.4	Land use maps and Ikonos imagery.....	339
Figure 25.5	Map spatial plan Banjarbaru	339
Figure 25.6	Banjarbaru City geohydrology Map	340
Figure 25.7	Banjarbaru City Watershed Map.....	340
Figure 28.1	Correlation between oil content and TMP value	355
Figure 28.2.	Correlation between oil content and temperature	356
Figure 28.3	Correlation between fux value and TMP	360
Figure 28.4	Correlation between fux value and temperature	361
Figure 30.1	Study area.....	386
Figure 30.2	Mean and standard deviation of daily air and water temperatures (T_a and T_w) at Melak and Belayan sites.....	387
Figure 30.3	Monthly changes in Rms 7-days of daily air and water temperatures at Melak and Belayan sites.....	388
Figure 31.1	Calibration Curve of <i>full-energy</i> detection efficiency (ϵ_p) on the various energy γ at the distance of detector and surface of sample 50 mm (level 1), 150 mm (level 3), and 250 mm (level 5) respectively.....	398

List of Figures

Figure 31.2	Curve of Peak to Total Ratio (P/T) versus energy of gamma (γ)..	399
Figure 31.3	Spectrum of gamma energy peaks for elements obtained from solid sample of Hp-X1 irradiated in reactor for 4 hours.	400
Figure 32.1	Experimental set up conventional ozonation process	406
Figure 32.2	Concentration of residual ozone at AOP and conventional ozonation.....	408
Figure 32.3	Organic Content of the samples	408
Figure 32.4	Degradation of Fe ²⁺ on samples.....	409
Figure 32.5	The effect of concentration residual of ozone on efficiency	410

List of Tables

Table 3.1	Appropriate Institution for CPR Management.....	36
Table 3.2	Water Right Regimes	37
Table 4.1	Four types of social structure «ways of life» according to Douglas (1974) and Thompson, Ellis and Wildawsky (1990)	55
Table 4.2	Four ways of life responses to water governance issues according to Hoekstra (1999).....	56
Table 4.3	Analysis on various water governance issues (frst part)	76
Table 4.4	Analysis on various water governance issues (second part).....	78
Table 4.5	Timeline comparison of the governing system, water governance milestones and water engineering feats in Indonesia (1816-present).....	84
Table 5.1	National Water Balance Year 2001 (x 1.000.000 m ³).....	94
Table 6.1	Type of access to water.....	101
Table 6.2	Sample of the respondent	106
Table 6.3	Characteristics of respondents from the aspect of water source	107
Table 6.4	Standard statistics	108
Table 6.5	Number of respondents in each type of community group	109
Table 6.6	Estimation results (Toyomarto).....	110
Table 6.7	Estimation results (Candi Renggo)	110
Table 7.1	Type access to clean water.....	123
Table 7.2	Number of respondents in each community group.....	124
Table 7.3	Indices of centrality of the most important respondent.....	130
Table 7.4	Characteristics of the most important respondent.....	130
Table 7.5	Characteristics of the most important respondent.....	131
Table 7.6	Cohesion of the respondent.....	131
Table 9.1	Factors and sub factors influencing sustainability of water supply system	154

List of Tables

Table 9.2	Installation cost and water tariff in 1999	157
Table 9.3	Weight and rank of sustainability factors	158
Table 9.4	Weight and rank of sustainability sub-factors	159
Table 10.1	Recommendations on each functional area.....	171
Table 10.2	Plantation species can be planted in water spring conservation area	171
Table 10.3	Recommendations on each functional area.....	174
Table 10.4	Plantation species can be planted in water spring conservation area	174
Table 10.5	Recommendations on each functional area.....	177
Table 10.6	Plantation species can be planted in water spring conservation area	177
Table 10.7	The detail of water springs management planning treaty recommendation	178
Table 10.8	Government affairs districts that can be handed over to village ...	178
Table 11.1	Benefit and obstacle water resources management in Yogyakarta	185
Table 12.1	BWK's service center Malang.....	195
Table 12.2	Average water production.....	198
Table 12.3	Water supply system in Malang City.....	199
Table 13.1	Water usage for Banda Aceh	210
Table 13.2	The extension of water usage for Banda Aceh.....	212
Table 14.1	Water demand and supply.....	220
Table 16.1	Annual rain fall (mm) and average Welang River debit (m ³ /s).....	232
Table 16.2	Chi Square Test.....	235
Table 16.3	Conflict of interest mapping in Krabyakan Spring water utilization.....	237
Table 17.1	Calculation Slovin	242
Table 17.2	Age of ancient buildings.....	247
Table 17.3	Ownership status of ancient buildings	248

Table 17.4	How to obtain the ancient buildings	248
Table 17.5	Crosstab analysis of characteristics of ancient buildings	248
Table 17.6	Reason maintaining function buildings	249
Table 17.7	Physical changes of ancient buildings.....	249
Table 17.8	Environmental quality in the area South Loji	250
Table 17.9	Damage level of ancient buildings in the area South Loji	252
Table 17.10	Referral criteria for environmental conservation	253
Table 17.11	Referral criteria for buildings conservation	254
Table 17.12	Preservation of ancient buildings according referrals	254
Table 18.1	List the functions and extent of the area in sub- sub-watershed Riam Kanan.....	264
Table 19.1	Rainfall data.....	270
Table 19.2	Variable and sub-variable as the UWA determinant.....	276
Table 19.3	Table scoring and weight process	277
Table 19.4	Size of erosion and fow surface in laboratory over 180 days in the Tanjungharjo Village	280
Table 19.5	Surface fow volume reduction on every area of downstream UWA.....	280
Table 20.1	To find out the water need of house connection type	285
Table 20.2	Number of households, residents, ratio of sex, and average of number of household's member as the result from census in 2000	287
Table 20.3	Recapitulation of water need per liter/person/day for the type of village housing in Malang City.....	289
Table 20.4	Recapitulation of water need per liter/person/day for the type of real estate housing in Malang City	289
Table 21.1	Watershed characteristics of Tapan and Dumpul sub-sub watershed.....	296
Table 21.2	Average runoff characteristics of Tapan and Dumpul sub-sub watersheds.....	296
Table 23.1	Questionnaires contents	317

List of Tables

Table 23.2	The summary result	320
Table 25.1	The development of underground water level in some weels in Banjarbaru (CAT Banjarmasin- Palangkaraya).....	333
Table 25.2	Results of analysis for the prediction of discharge borehole PDAM Banjar Diamond	338
Table 27.1	Summary of interviews	348
Table 28.1	Oil content after and before <i>pre-treatment</i>	355
Table 28.2	Oil containing in water at TMP and temperature variation	357
Table 28.3	Standard quality of reinjection water (Qiao, X, 2008)	357
Table 28.4	Standard regulation for produced water disposal	358
Table 28.5	Comparing before and after pre-treatment	358
Table 28.6	pH comparing at TMP value and temperature variety	359
Table 28.7	Comparing of TSS value after and before pre-treatment	359
Table 28.8	TSS Comparing at TMP value and temperature variety	360
Table 29.1	Waste water quality standard of industrial activities according to environmental Ministerial Regulation No. Kep-51/ MENLH/10/1995 (EMRRI, 1995)	367
Table 29.2	Water quality criteria according class, conforming Government Regulation No. 82 Year of (GRRI, 2011)	368
Table 29.3	Drinking and clean water standart quality according to Health Ministerial Regulation No. 416 /MENKES/PER/IX/1990 (HMRI, 1990)	369
Table 29.4	Common industrial waste water treatment methods and applications (Douglas, 1982).....	371
Table 29.5	Trace nutrient requirements for biological oxidation (Wesley, 1989).....	372
Table 29.6	Some examples of bacterial heavy metal and radionuclide accumulation (Fry et.al, 1992).....	373
Table 29.7	Description of bacteria cell components functioning to support biosorption (Tchobanoglous, 2003).	374
Table 31.1	Measurement results of reactor parameters for each canal of irradiation facility at Reactor of G.A Siwabessy.	399

Table 31.2 The analysis result of elements contained in the solid and liquid of water samples from filtering process using k_0 -NAA method. 401

Table 31.3 Identification of the liquid of water and solid wastes from filtering process based on the LPHC and its recommendation for further treatment of the both wastes. 403

Table 32.1 Water samples characteristic 407

Chapter 1

Water Supply Management System and Social Capital

Erwin R. H. ...

1.1 Introduction

Water supply is one of the basic needs of the nation and its people. In Indonesia, water supply is one of the most important services provided by the government. The water supply system is a complex system that involves many stakeholders, including the government, private sector, and community. The water supply system is a complex system that involves many stakeholders, including the government, private sector, and community. The water supply system is a complex system that involves many stakeholders, including the government, private sector, and community. The water supply system is a complex system that involves many stakeholders, including the government, private sector, and community.

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Chapter 28

Produced Water Treatment Using Polyamide Thin-Film Composite Reverse Osmosis Membrane

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28.1 Introduction

Water is one of the human basic needs and provided for almost three fourth of earth surface such as in ocean, lake, river, etc. Produced water is a byproduct that produced from oil wells (Murray, G.C., 2003). It also becomes the highest waste that produced during oil extraction (Ali, S.A., 1999, Khatib., Z., 2003). The method such as thermal heavy oil recovery that is oil sand processing and steam assisted gravity drainage (SAGD) the volume ratio produced between water and oil generally can be reach up to 3-12:1. This ratio shows how many produced water generated from an oil well. As Oil stock decreasing in wells, produced water generated from the well will increase because the need of injection water into well also increasing.

According to the International Association of Oil and Gas Producers (OGP), about 17 million m³ produced water obtain in a day around the world both at *on shore* and *off shore*. This amount is equivalent to 120 million barrel oil per day. On the other hands, 15-20 billion barrel produced water generated every year in USA (Veil, J.A., 2004).

Treating and recycling produced water very important in order to maintain the

production of oil and gas. Furthermore, organic impurities containing in produced water can be lead to the serious problem to environment, Industry and human life. This contaminant will make corrosion in pipe and higher energy to transport. Conventional treatment of this water consisted of gravity separation and skimming, dissolved air foatation, de-emulsification, coagulation, and focculation (Cline, J.T., 1998). However, it has some weakness such as at gravity separation process need longer time to separate, difficult to separate oil and water when the oil is very small, and this process also can not yield output that meet the quality requirement. In addition, it also yielded high volume sludge and need high operation cost.

Membrane filtration process such as reverse osmosis offers many advantages for treating oiled water. For instance, this process do not need chemical additive, membrane can be used in repeatedly and easy in operation since membrane is an automatic device.

This research goal are to determine of operation condition that obtained the lowest oil content in water by varied the temperature and trans membrane pressure, to analyze pH, oil content and suspended solid in permeate, and to analyze the effect of parameter to fux and membrane permeability.

28.2 Materials and Methods

28.2.1 Materials

Produced water was obtained from one of the company in Sumatra Island. It had been passed from Gas Boot and Wash Tank, so that obtained treated produced water with oil content 26.33 mg/L.

A) Membrane Specification

This research was done in reverse osmosis membrane with spiral wound type membrane. The membrane was bought from a market in Indonesia and manufactured by Dow Film tech with series TW30-1812-100. Membrane module is spiral wound with material used is Polyamide Thin-Film Composite (TFC). Maximum temperature Operation that can be operated is 113F (45°C) and maximum membrane pressure operation is 150 psi (10 bar) while maximum passing fow rate on membrane is 2.0 gpm (7.6 lpm). Membrane dimension itself has diameter to length is 2" to 12".

B) Membrane Apparatus

Membrane apparatus was bought from Institute Technology Bandung (ITB) with maximum pump pressure is 110 psi and pump type is diaphragm pump. Moreover, the feed tank is modified so that can be operated in different temperature.

28.2.2 Methods

The research started by waste sample pretreatment using centrifugation at 5000 rpm. After that the sample was passed to reverse osmosis membrane. The variable studied in this research are trans membrane pressure (TMP) from 1-5 bar and temperature from 36-40°C at operated TMP that yielded permeate with the lowest oil

content.

28.2.3 Analysis

Analysis of permeate consisted of oil content, total suspended solid (TSS), and pH. Oil content analysis was done by SMWW-5520 C Partition-Infrared Method (FTIR spektrofotometri) method at wavelength 2900-3000. Meanwhile, TSS analysis was done by gravimetric method and pH value detected by pH meter.

28.3 Results and Discussion

28.3.1 Effect of trans membrane pressure and temperature on oil content in permeate

Waste produced water used in this research has been processed by Gas Boot and Wash Tank so that the oil content value measured in this sample was 26.33 mg/L.

Table 28.1 Oil content after and before *pre-treatment*

No	Sample	Oil Content (mg/L)
1	Before Pre-treatment	26.33
2	After Pre-treatment	18.33

This produced water then centrifuged at 5000 rpm for 10 minutes so that the oil content in the sample reduced to 18.33 mg/L that shown in Table 28.1.

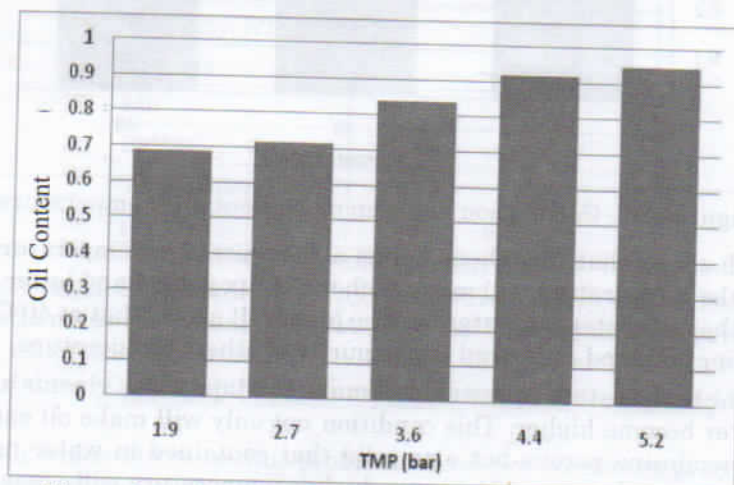


Figure 28.1 Correlation between oil content and TMP value

Membrane selectivity is membrane ability to separated components from the feed. Ideally, membrane has high selectivity and permeability. Refer to the figure 1,

higher the TMP value will make oil concentration on permeate become higher since TMP value proportional to the flux. Generally, a phenomenon that flux will oppose the selectivity occurs in membrane process so that higher the flux will tend to make lower the selectivity. The graph shows that the correlation between TMP value to the oil content that is oppose each other. This was caused by higher TMP value will make pressure in membrane become higher too and lead to the higher flux that passed the membrane. On the other hands, high pressure in membrane make oil molecules that stacked in the membrane surface pushed by those high pressure, this condition will make those molecules more easy to pass the membrane porous that lead to the decreasing in membrane selectivity.

Oil content that contaminated in permeate will be determined from this TMP variation and become the TMP that use for the next variation that is temperature. The operation itself will be chosen for TMP with the lowest oil that containing in permeate. The lowest oil content is obtained from TMP that is 1.9 bar. So that, this TMP will be used for next operation.

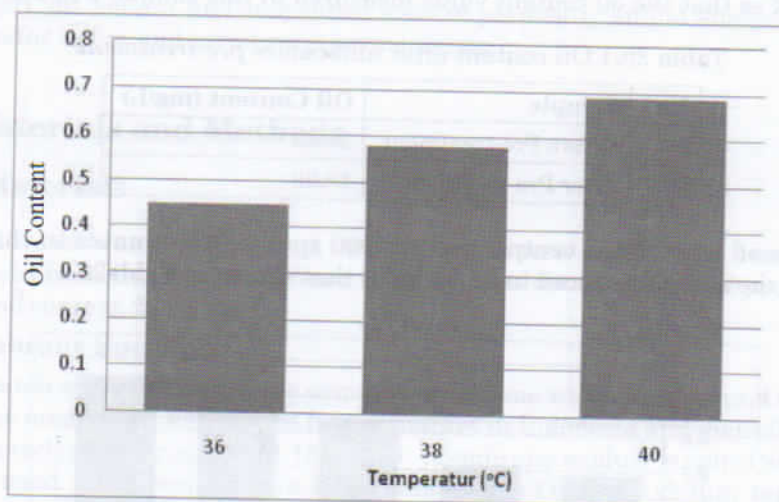


Figure 28.2. Correlation between oil content and temperature

The graph shows that this phenomenon also occurred in temperature variation that higher the temperature will make higher the flux gained and lower selectivity obtained so that oil content in water become higher. It shows that at 40°C the lowest purity of water obtained compared to the purity of others temperature.

The higher temperature operated will make the liquid less viscous and oil solubility in water become higher. This condition not only will make oil easier to penetrate the membrane porous but also solid that contained in water more soluble that make permeate less pure. Moreover, higher temperature will cause swelling in membrane and make the membrane porous larger so membrane become less selective.

Table 28.2 Oil containing in water at TMP and temperature variation

No	TMP value(bar)	Temperature(°C)	Oil Content(mg/L)
1	1.9	40	0.69
2	2.7	40	0.72
3	3.6	40	0.84
4	4.4	40	0.92
5	5.2	40	0.95
1	36	1.9	0.45
2	38	1.9	0.58
3	40	1.9	0.69

One of the purposes of this research is yielded permeate from the process hopefully can meet the reinjection water standard quality. This reinjection water will be injected to the oil well to overcome the problem that caused by less oil containing in the well. Unfortunately, reinjection water has their own standard and differ between one well to others. Table 28.3 shows the standard quality of reinjection water from Daqing oilfield.

Table 28.3 Standard quality of reinjection water (Qiao, X, 2008)

Parameter	Water reinjection standar
Oil Content, mg/L	<0.1
SS content, mg/L	<0.1
Turbidity, NTU	/
Total Fe	<0.5
Mn	/
Sulfde	<0.5
Total Mineral	/
pH	6-9

/: no specific standard

It shows that oil concentration in injection water is very small that is less than 0.1 mg/L, otherwise the research shows that the best result from reverse osmosis separation using this membrane only yielded 0.45 mg/L at TMP 1.9 bar and 36°C. This value did not meet the standard yet since it was upper than it should be that is 0.1 mg/L.

One factor which can cause this problem was at pre-treatment process that used centrifuge and gained oil content in the sample laid to 18.33 mg/L. this value still too high for reverse osmosis membrane processes.

Oil contained in produced water is dispersed oil. Addition of corrosion inhibitor at the oil well can make oil form an emulsion that has more chemically stable. In result, this oil cannot be separated by centrifugation effectively at those conditions.

It also shown from the data after and before pretreatment that was not significantly different.

Although this water could not meet the standard quality to be reinjection water, the result shows that it met the Indonesian standard for disposal produced water to the environment that is less than 15 mg/L. Standard regulation for this disposal produced water shown in table 28.4. Treatment produced water using reverse osmosis membrane could obtain permeate with oil content 0.4-1 mg/L. it mean that even the water cannot meet the requirement to be reinjection water it is safe to dispose to the environment according to that regulation.

Table 28.4 Standard Regulation for Produced Water Disposal
(Syafruddin, M., 2008)

Waste Produced Water Disposal	Oil Concentration (mg/L)
OSPAR convention for offshore	30
US Standard for onshore	29
US Standard for offshore	29
Atlantic Ocean and North Sea	30
Indonesian Standard Regulation	15

28.3.2 Effect of TMP value and temperature on pH

Table 28.5 comparing before and after pre-treatment

No	Sample	pH
1	Before pre-treatment	5.6
2	After pre-treatment	7.1

From the table can be seen that by pretreatment done to the sample yielded that pH value after pretreatment is higher than before pretreatment. Generally, chemical additives were added to the produced water to prevent solidification during oil milling. Some of this additive usually has an acid base in result by adding those would make pH in produced water decreased. Moreover, natural soluble organic compound also produced in those water that lead to the high acidity in those water.

From Table 28.6 can be seen that feed pH is lower than the yielded permeate. Separation process using reverse osmosis membrane had been rejected some acid component from feed water so that permeate pH value become higher than before separation.

Lowest TMP (1.9 bar) and temperature (36°C) obtained permeate with highest purity. pH at this condition was 7.6. It proved that when then purity of permeate is high many of components in produced water separated, included acidic materials. Average permeate pH value that obtained was ranged from 7-8. It means that this pH had been fulfilling the standard quality for reinjection water.

Table 28.6 pH comparing at TMP value and temperature variety

No	TMP value (bar)	Temperature (°C)	pH	
			Sample	Permeate
1	1.9	40	7.1	7.58
2	2.7	40	7.1	7.56
3	3.6	40	7.1	7.52
4	4.4	40	7.1	7.5
5	5.2	40	7.1	7.48
1	36	1.9	7.1	7.58
2	38	1.9	7.1	7.6
3	40	1.9	7.1	7.6

28.3.3 Effect of TMP and temperature on total suspended solid (TSS)

Total suspended solid contaminated in produced water is a solid that precipitated such as sand, salts, clay, carbonate, corrosion product and other suspended solid gained from oil milling.

Table 28.7 Comparing of TSS value after and before pre-treatment

No	Sample	TSS (mg/L)
1	Before pre-treatment	527
2	After pre-treatment	15.2

The table shows, suspended solid concentration on produced water was so high and this can be seen too from the water turbidity. Commonly, turbidity is close to the suspended solid level that contained in water. It also shows that by pretreatment done to the sample had been greatly decreased suspended solid concentration. It mean that centrifugation method that applied had been effectively reduced this impurities. It separation principal is using centrifugal force in order to precipitated molecule that has bigger density and form separated layer between them.

The table above shows that TSS value that gained from TMP and temperature variation did significantly different. It shows that neither temperature nor TMP significantly influenced the membrane performance to separate suspended solid.

TSS value obtained from 0-0.1 mg/L, so that, it can meet the quality of reinjection water. This result is appropriate to the reverse osmosis membrane working principal that can reject suspended solid excellently.

Table 28.8 TSS Comparing at TMP value and temperature variety

No	TMP value(bar)	Temperature(°C)	Oil Content(mg/L)
1	1.9	40	0
2	2.7	40	0
3	3.6	40	0.1
4	4.4	40	0.1
5	5.2	40	0.1
1	36	1.9	0
2	38	1.9	0
3	40	1.9	0

28.3.4 Effect of TMP on permeate flux

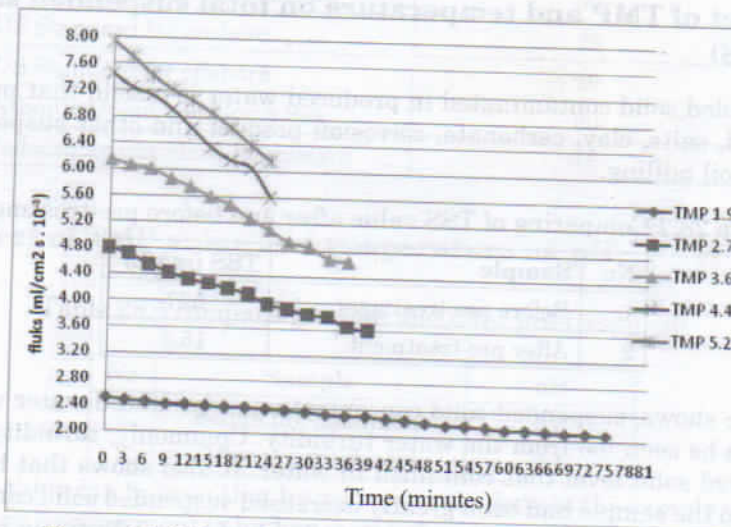


Figure 28.3 Correlation between flux value and TMP

Flux is a factor that always be measured in membrane research to process produced water because flux is one important factor in membrane performance. Flux defined as:

$$J = \frac{V}{A.t} \quad (1a)$$

Flux data in this research was obtained by calculating time required for gaining 10 mL permeate. Data sampling was done in 3 minutes interval time until obtained 5500 mL permeate. According to the figure 3, the longest experiment time will re -

sult in smallest fux fowrate. This was caused by longer experiment time will make membrane performance decrease because of accumulation of material or impurities in membrane surface. If this condition do not solved immediately will lead to the fouling that make membrane performance significantly decreased.

In addition, the graph also shows the effect of trans membrane pressure (TMP) to the fux membrane. Higher TMP used in process will result in higher fux that gained.

TMP is a driving force in membrane separation. During the separation process, the pressure on feed is higher than the permeate. This differential made the feed few through the membrane porous. Higher TMP used will make pressure difference higher and vice versa. The graph shows that at the lowest TMP applied that is 1.9 bar need longer time than others TMP. Moreover, the graph shows that the fux at those TMP is lower than others.

28.3.5 Effect of temperature on permeate fux

This variation done at TMP value which yielded lowest oil content in permeate in order to gain produced water that can meet the standard quality of reinjection water. Figure 28.4 show that increasing in temperature did not significantly affect the fux.

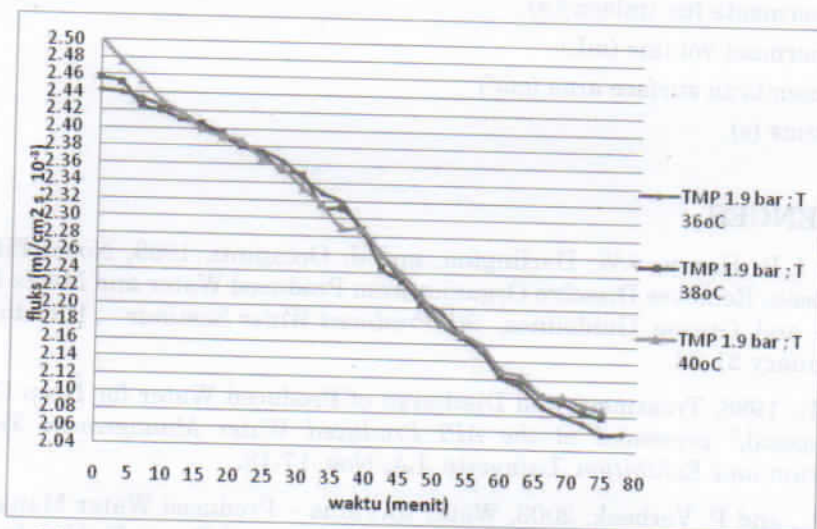


Figure 28.4 Correlation between fux value and temperature

Theoretically, temperature will affect on fux where higher temperature applied will make fux higher too. This is caused by the higher temperature will result in fluid less viscous and oil solubility and suspended solid increase. In result, the fluids tend to be easier to pass the membrane porous. In this research, the highest fux gained was at 40°C while the temperature variation did not significantly different so that the fux did not show significantly difference.

28.4 Conclusions

It can be concluded from this research that the best permeate obtained had oil content 0.45 mg/L, pH 7.6 and TSS value can be ignored since it was very small. According to the reinjection water standard quality from Daqing oilfield, it can be claimed that this process had been fulfill the TSS and pH value but had not pass the oil content requirement yet. However, permeate that obtained from this process had meet the Indonesian produced water disposal.

The best operation that is yielded permeates with oil content 0.45 mg/L is at TMP 1.9 bar and temperature 36°C. TMP changed proportionally to the permeate flux and reversed to the selectivity. This phenomenon was also occurring in temperature.

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Nomenclature

- J : permeate flux (ml/cm².s)
 V : permeate volume (mL)
 A : membran surface area (cm²)
 t : time (s)

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Chapter 29

Removal Phenomena of Cation, Anion, Inorganic and Organic Contents on Water Treatment for Preparation of Raw Water for Drinking Water

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29.1 Introduction

Water is one of the most essential resources for life. Clean water is needed by humans for the daily necessities, such as drinking, irrigation, agriculture, and industry. The quality of water is an important factor in determining the health of a community. The quality of water is determined by the presence of various substances, both inorganic and organic. The inorganic substances are minerals and salts, while the organic substances are natural and synthetic organic compounds. The presence of these substances in water can cause various health problems, such as skin irritation, respiratory problems, and cancer. Therefore, it is important to remove these substances from water before it is used for drinking. The removal of these substances from water can be done through various water treatment processes, such as coagulation, flocculation, sedimentation, filtration, and disinfection. Each process has its own advantages and disadvantages. The choice of water treatment process depends on the quality of the water to be treated and the requirements for the treated water. The goal of water treatment is to provide safe and healthy drinking water for the community.

The aim of this study is to investigate the removal of cation, anion, inorganic, and organic contents on water treatment for preparation of raw water for drinking water.