AIR-PURIFYING AND SELF-CLEANING URBAN INFRASTRUCTURE USING SUNLIGHT

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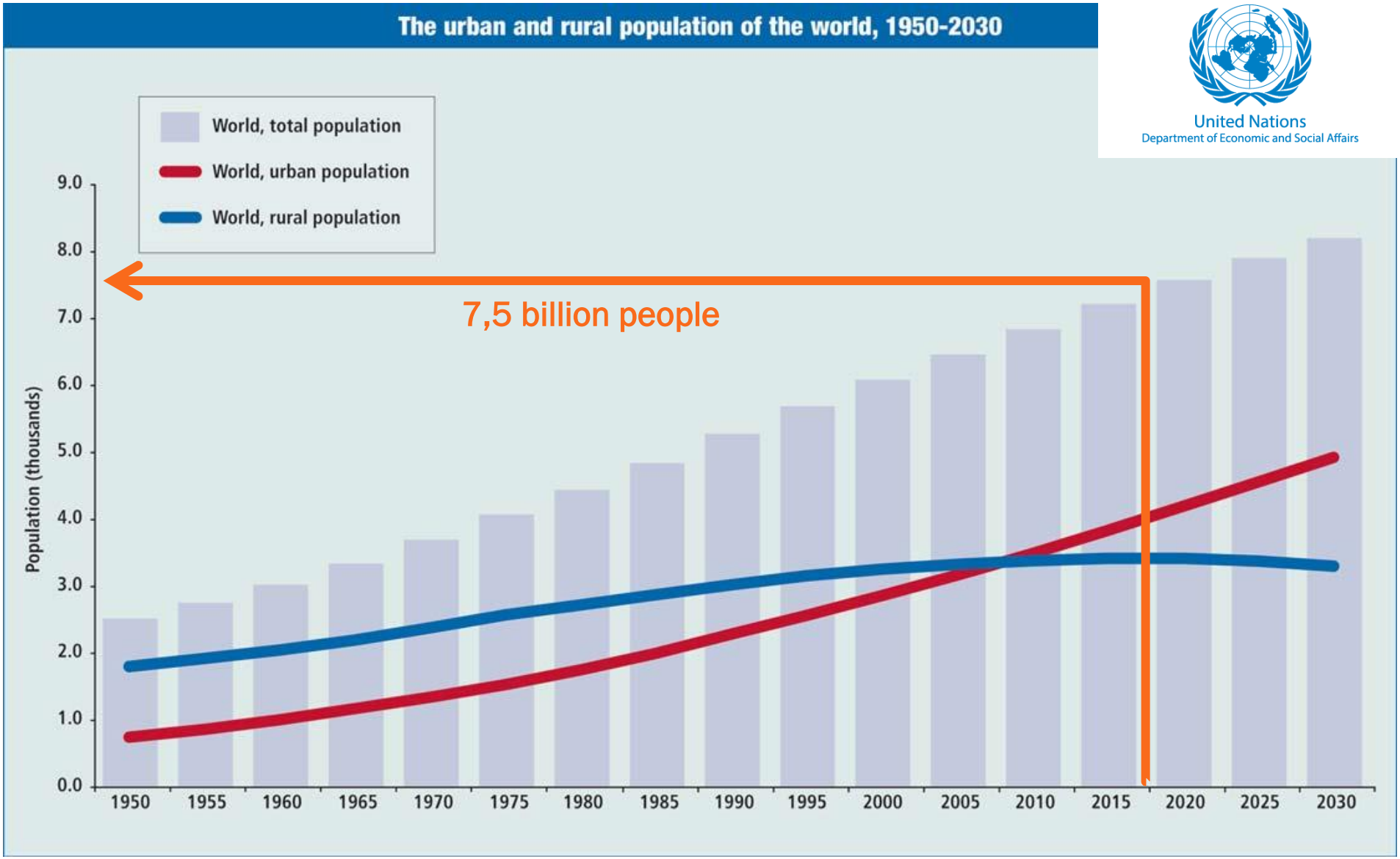
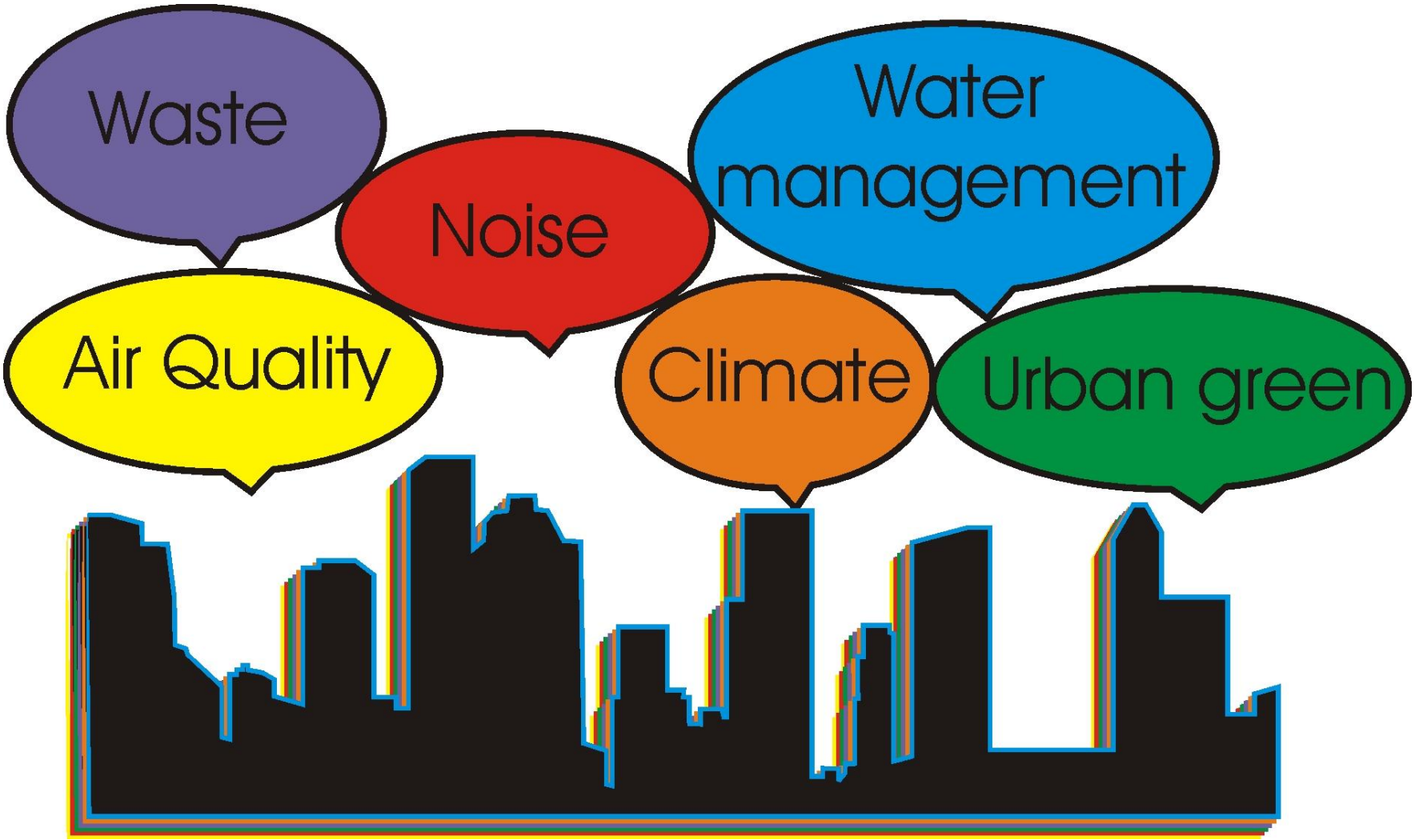
URBAN ENVIRONMENTAL PROBLEMS

I

URBAN ENVIRONMENTAL PROBLEMS



URBAN ENVIRONMENTAL PROBLEMS



Major Environmental Problems at Urban Scale

URBAN ENVIRONMENTAL PROBLEMS

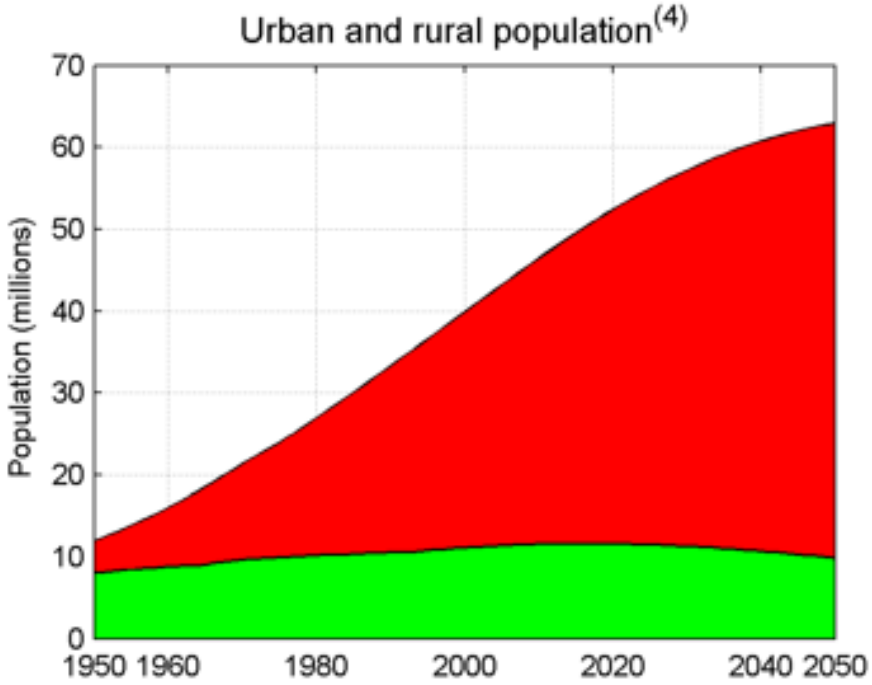
Air Quality

Hong Kong (China)

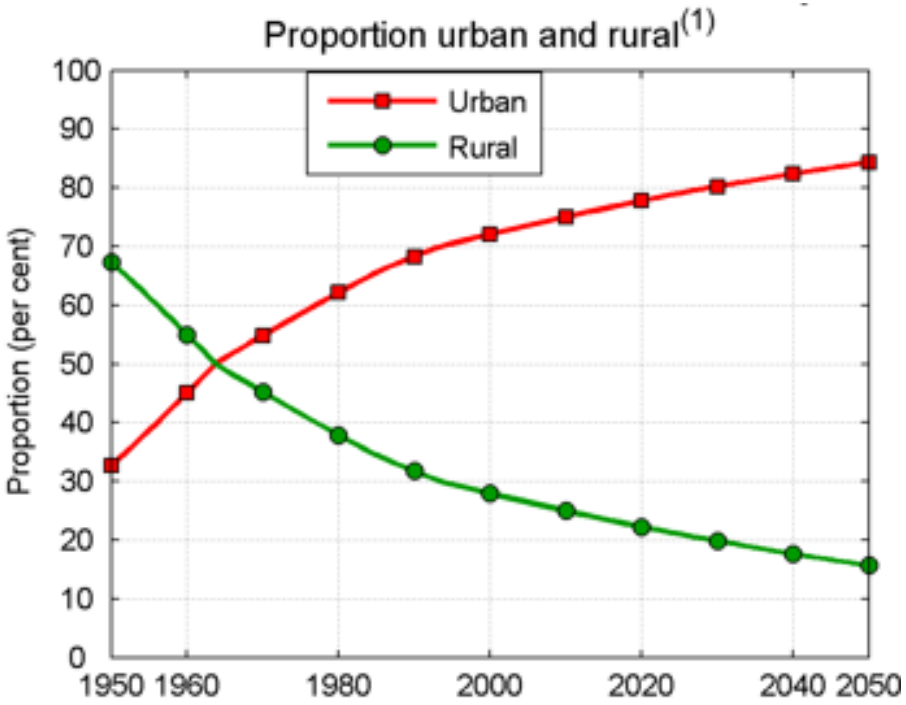
Building Deterioration

Halle (Germany)

URBAN ENVIRONMENTAL PROBLEMS



United Nations
Department of Economic and Social Affairs



Colombian population and urbanization

LOW AIR QUALITY

Formación de Smog Sobre Bogotá (Colombia)

Alerta Naranja en Medellin por Mala Calidad del Aire (Colombia)

Air quality in Medellín and Bogotá

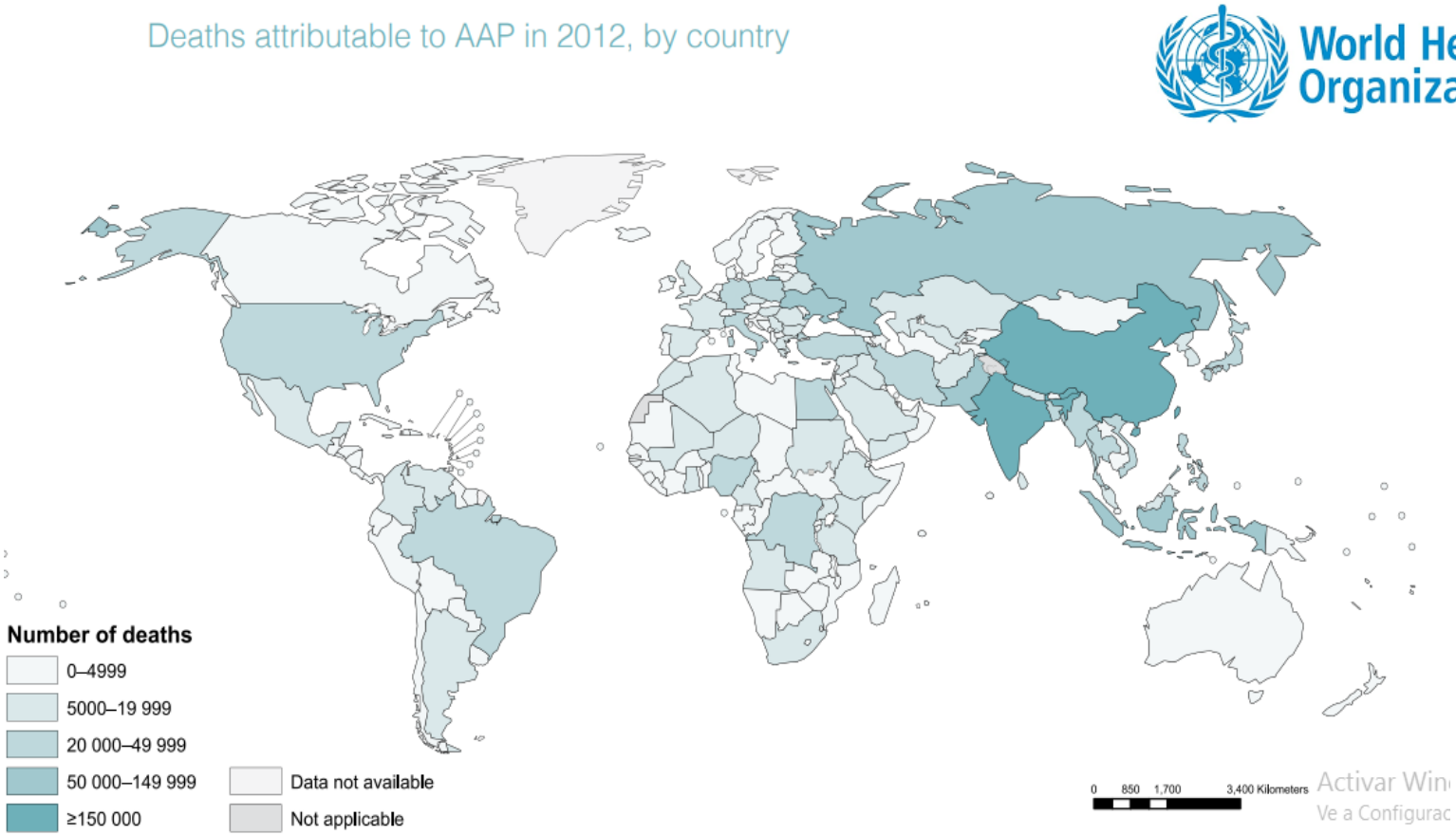
LOW AIR QUALITY

Contaminación Atmosférica Cali (El país, 2009)

Lugar	Contaminantes que superan la norma
Bucaramanga	PST, PM_{10}, Ozono, CO
Bogotá	PM_{10}, Ozono
Medellín	PST
Ibagué, Lérida, Espinal, San Luis	PST
Cali	Ozono, PM_{10} y CO
Yumbo y Palmira	SO_2, NO_2, Ozono
Acopi (Yumbo)	Plomo, PM_{10}
Santa Marta - Ciénaga	PST
Barranquilla	PM_{10} (información parcial)
Sogamoso	Ozono y PM_{10}
CAR (Zipa, Soacha, Nemocón, Ráquira)	PST, PM_{10}
Cauca (Villarica)	PST
Manizales, Pereira, Oriente antioqueño	Sin problemas
Cartagena	Sin información

Herrera Santos, C.M., El sector empresarial y la contaminación urbana en Colombia (2009).

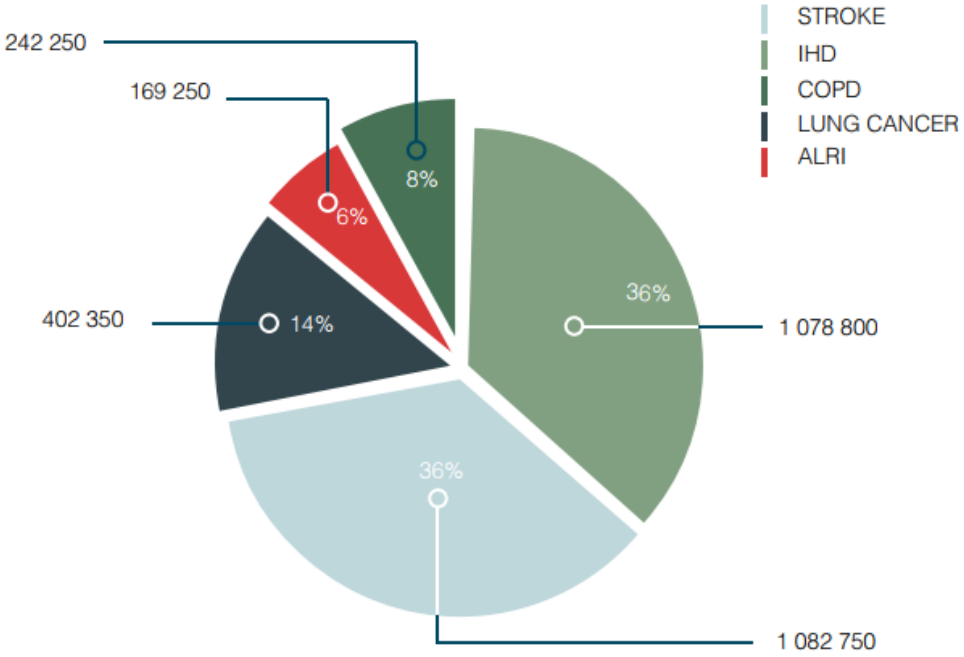
LOW AIR QUALITY



LOW AIR QUALITY

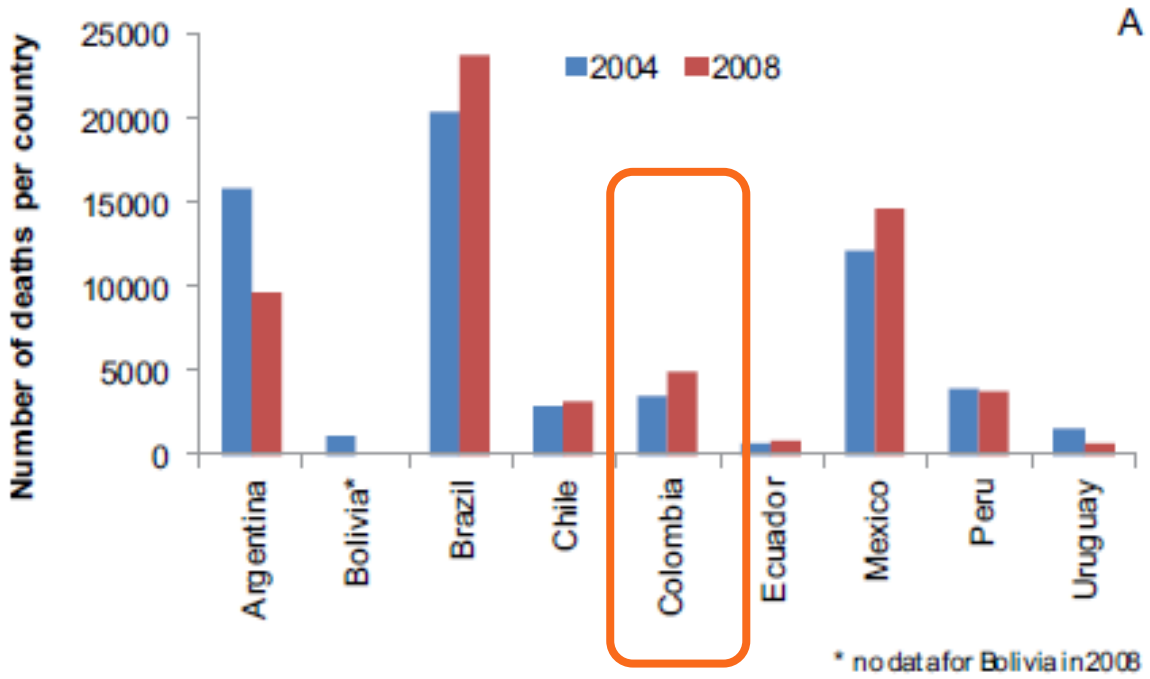
World Health Organization

Deaths attributable to AAP in 2012, by disease



Percentage represents percentage of total AAP burden. AAP: ambient air pollution; ALRI: acute lower respiratory disease; COPD: chronic obstructive pulmonary disease; IHD: ischaemic heart disease.

LOW AIR QUALITY

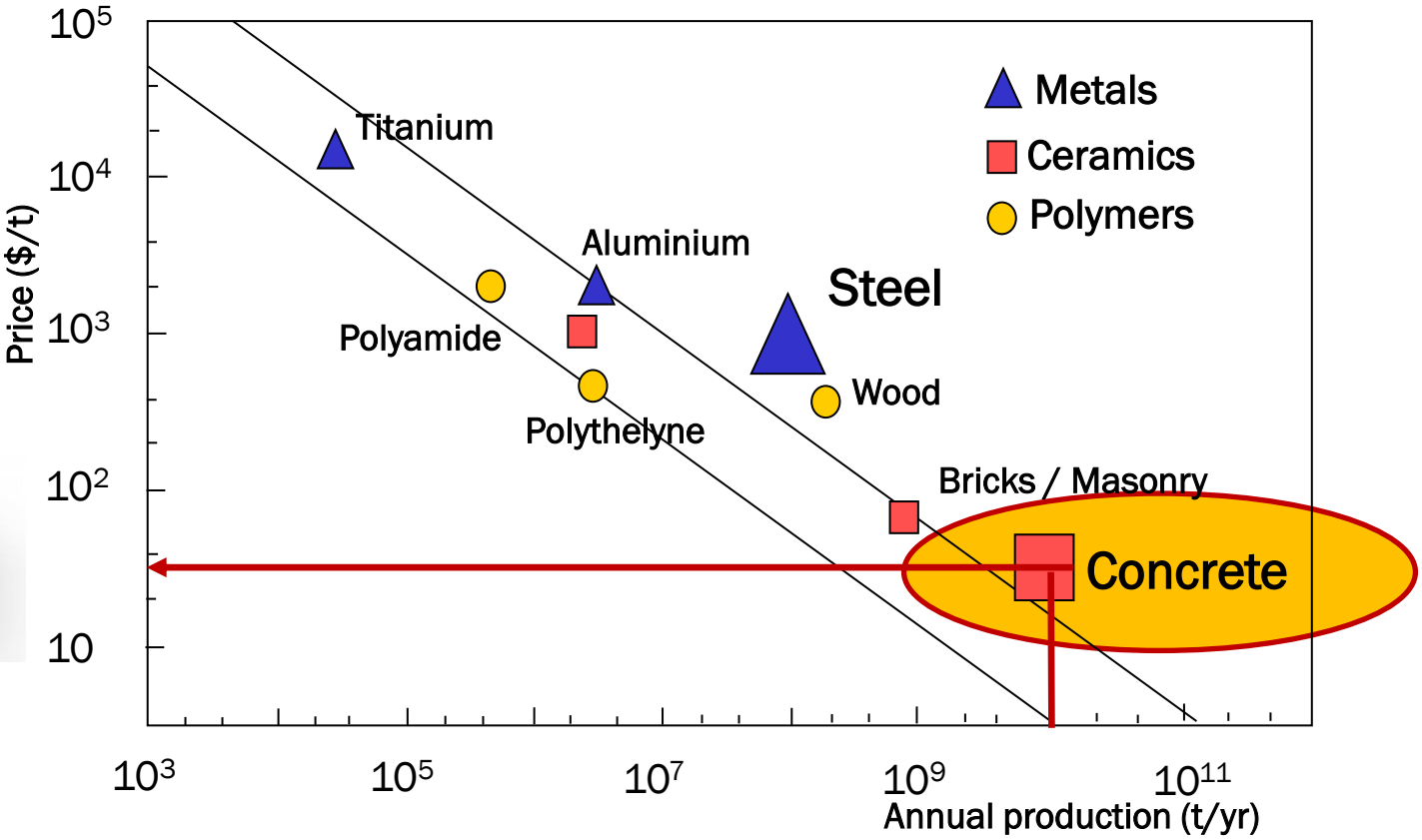


Clean Air Institute (2012)

URBAN SUSTAINIBILITY

II

URBAN SUSTAINABILITY

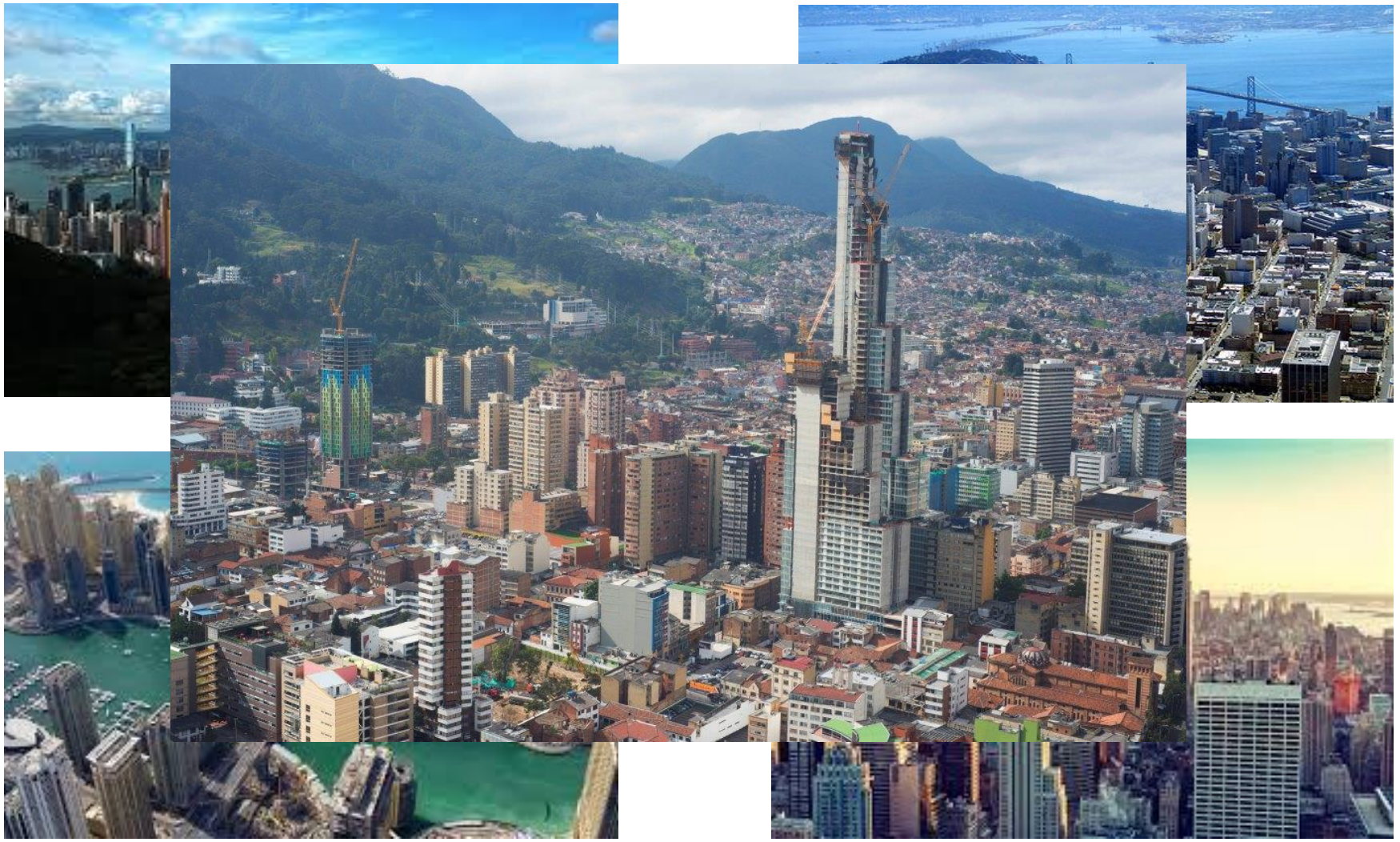


Source: *INTRODUCTION à LA SCIENCE DES MATÉRIAUX, Kurz,Mercier, Zambelli,. PPUR , 3rd ed 2002*

- Disponibilidad
- Fácil de usar y fabricar
- Durable
- Moldeable

USO DEL CONCRETO A NIVEL MUNDIAL

URBAN SUSTAINABILITY



USO DEL CONCRETO A NIVEL MUNDIAL

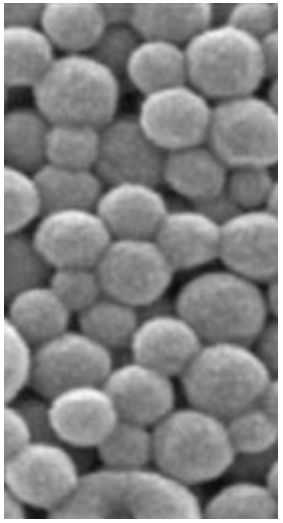
CONCRETE SUSTAINABILITY

Impacto Ambiental de los materiales de construcción convencionales

Cementantes Alternativos

Agregados reciclados

Aditivos especiales o recubrimientos: Nano-materiales



componentes de un concreto sostenible

TITANIUM DIOXIDE PHOTOCATALYSIS

Akira Fujishima - Japan (1942 - ....)

Nanopartículas de dióxido de titanio (TiO_2)

SCIENCEWATCH

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TITANIUM DIOXIDE PHOTOCATALYSIS

CHEMISTRY

Akira Fujishima
President, Tokyo University of Science, Special University Professor Emeritus, University of Tokyo, and Supreme Advisor, Kanagawa Academy of Science and Technology

Fujishima is suggested as a possible Nobel Prize winner "for the discovery of photocatalytic properties of titanium dioxide known as the Honda-Fujishima Effect"

Pontificia Universidad JAVERIANA Cali

PHOTOCATALYTIC BUILDING MATERIALS

III

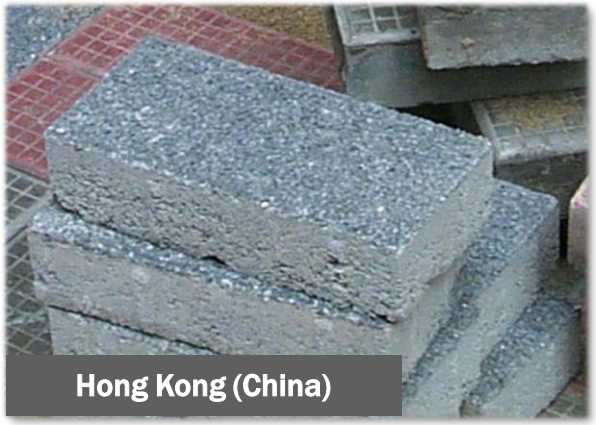
PHOTOCATALYTIC CEMENTITIOUS MATERIALS

Hong Kong (China)

Yu (2003)

Beeldens & Boonen (2011)

Brussels (Belgium)



Hong Kong (China)

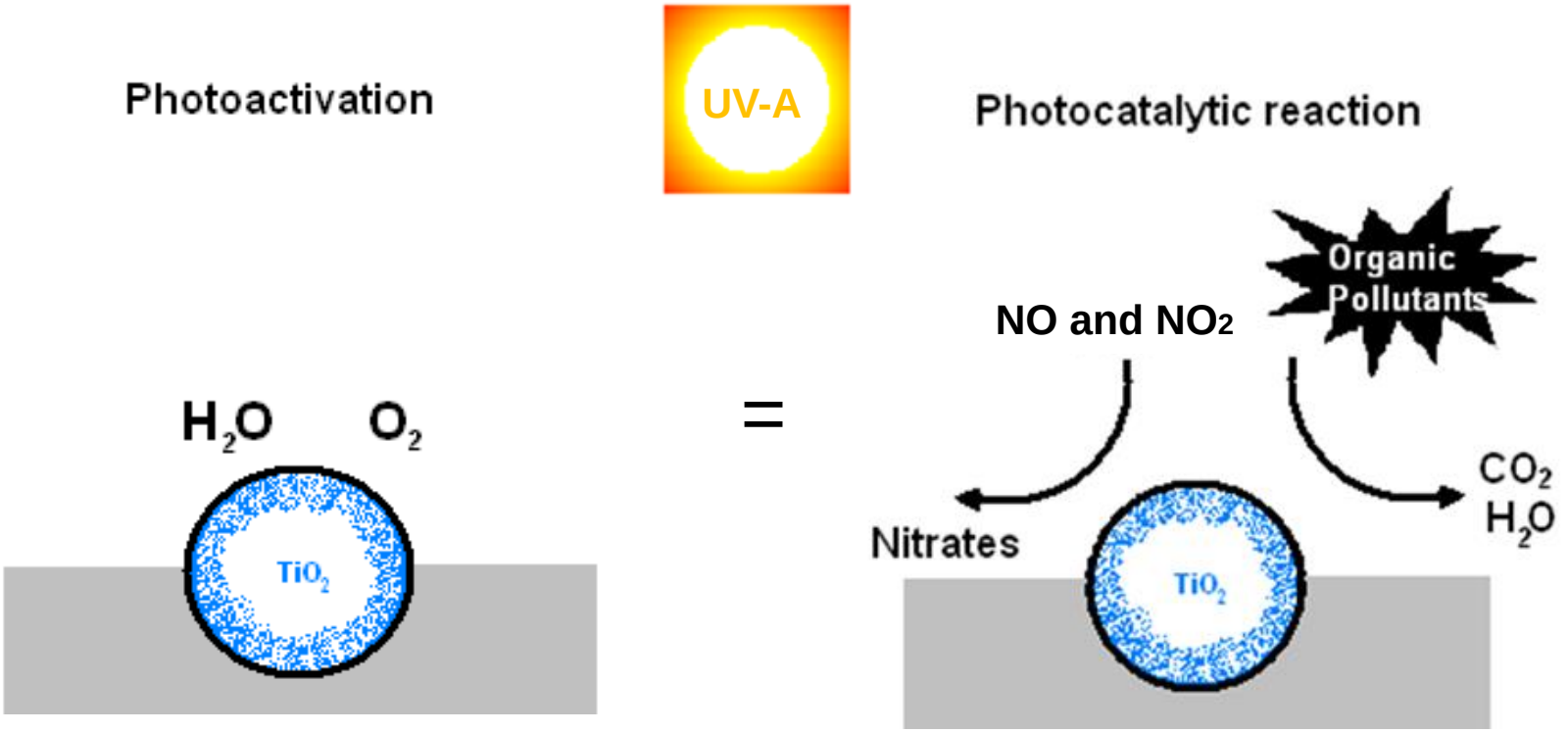
Yu (2003)

Beeldens (2007)

Antwerp (Belgium)

AIR PURIFICATION PROJECTS

TiO_2 in Building Materials

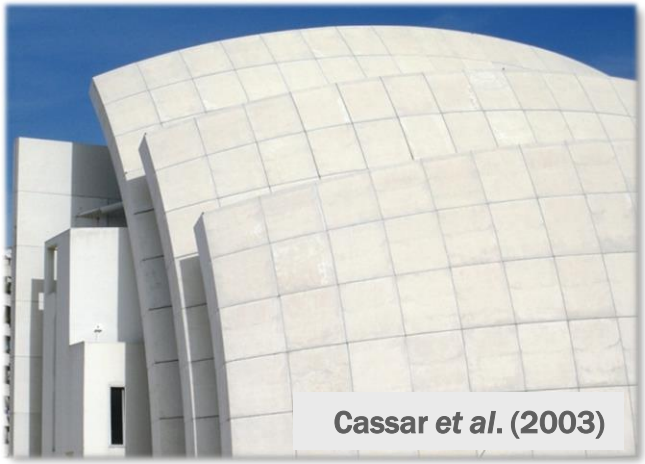


AIR PURIFICATION

PHOTOCATALYTIC CEMENTITIOUS MATERIALS

Rome (Italy)

Ostend (Belgium)

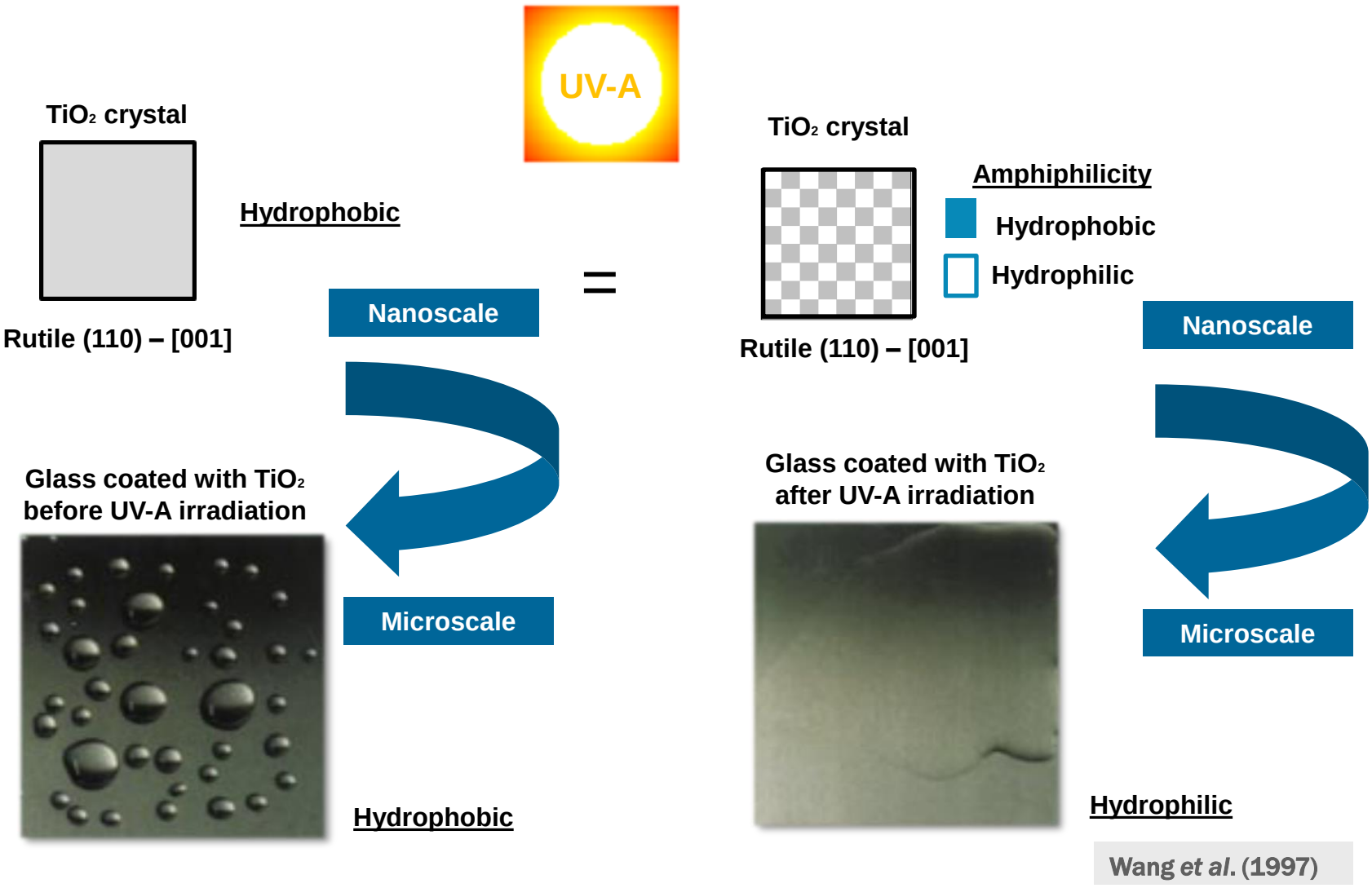


Rome (Italy)

Ostend (Belgium)

SELF-CLEANING PROJECTS

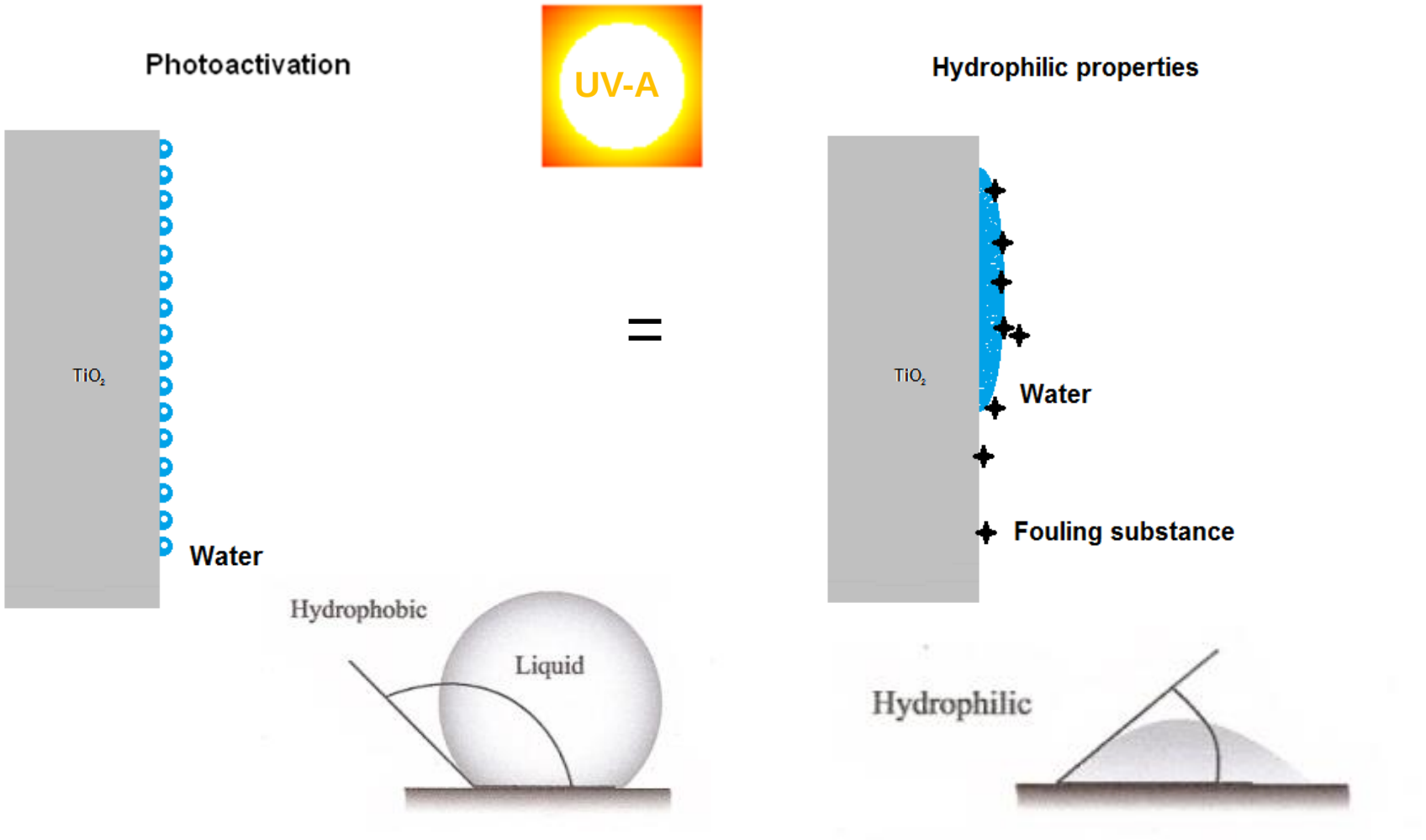
TiO_2 PHOTOCATALYSIS: HYDROPHILICITY



Wang *et al.* (1997)

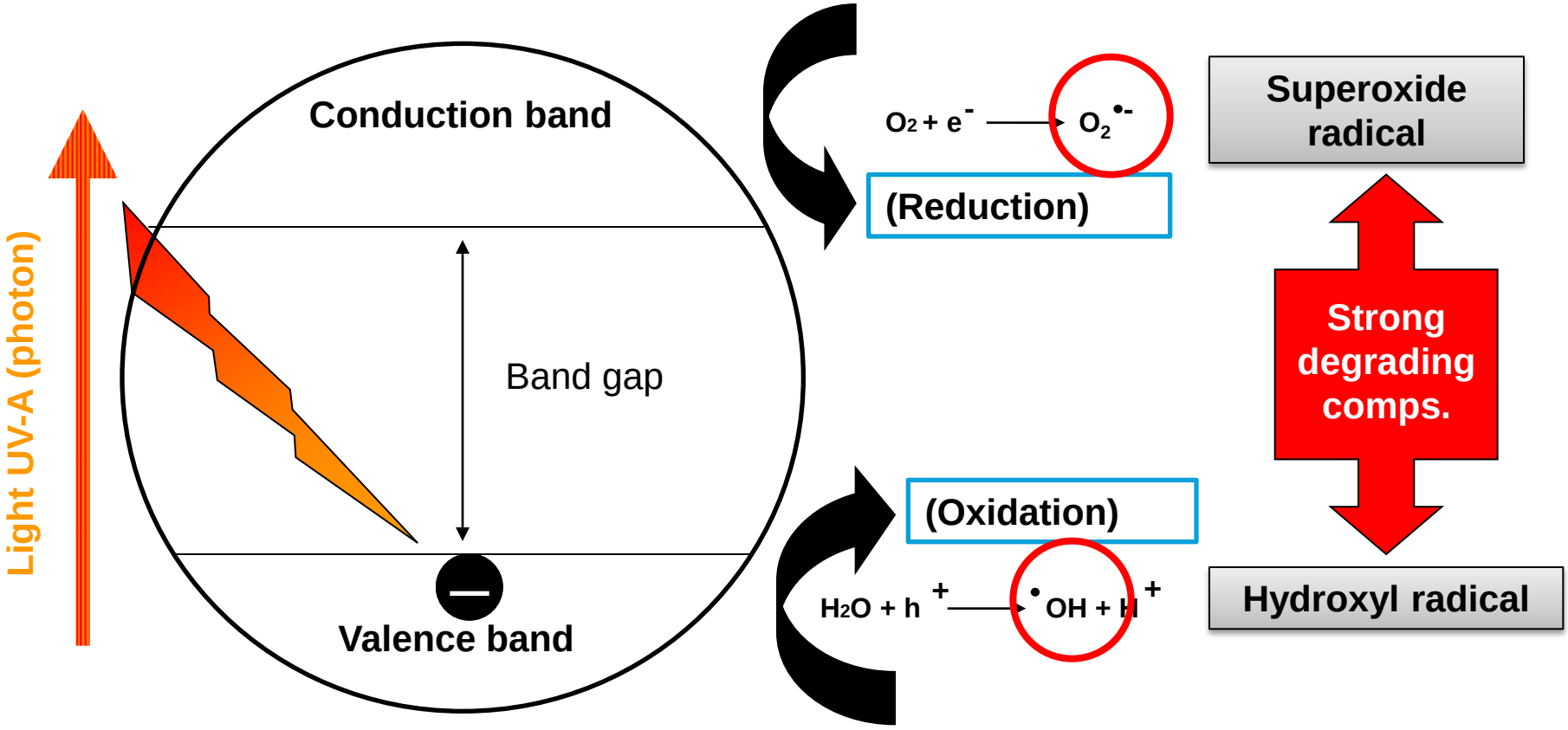
SELF-CLEANING

TiO_2 PHOTOCATALYSIS: HYDROPHILICITY



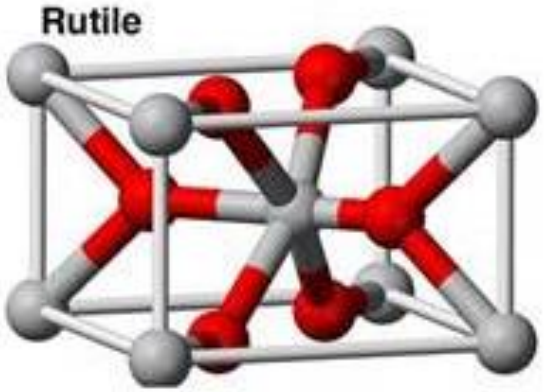
SELF- CLEANING

TiO_2 PHOTOCATALYSIS: BAND-GAP MODEL

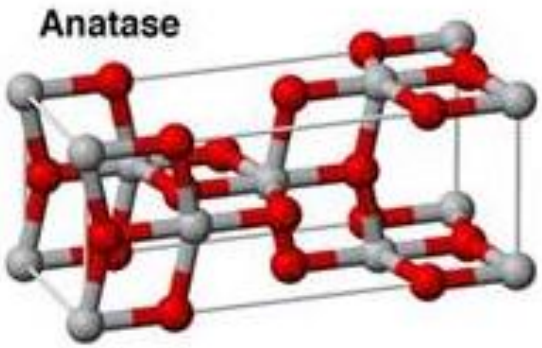


Hoffman *et al*. (1995)

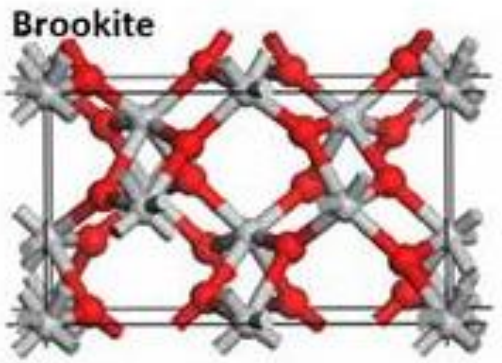
TiO_2 CRYSTAL STRUCTURES



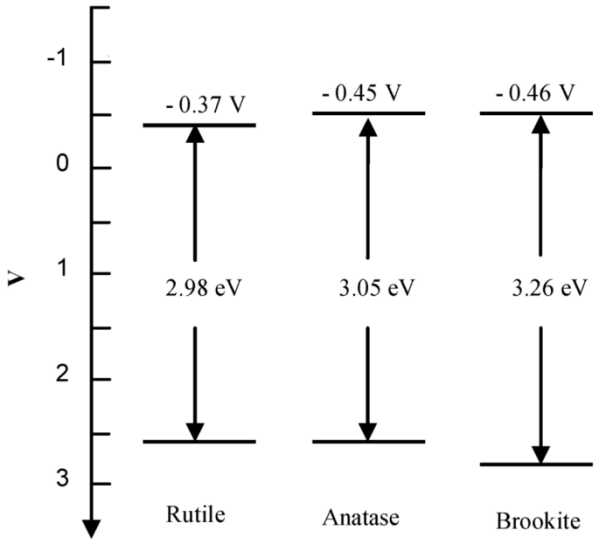
Tetragonal

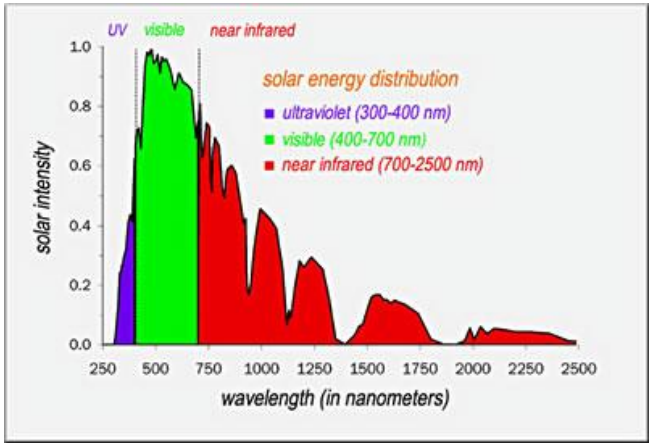


Tetragonal



Ortorrómbica





Di Paola, A.; Bellardita, M.; Ceccato, R.; Palmisano, L.; Parrino, F. Highly active photocatalytic TiO_2 powders obtained by thermohydrolysis of $TiCl_4$ in water. *J. Phys. Chem. C* **2009**, *113*, 15166–15174

CHALLENGES IN THE APPLICATION OF PHOTOCATALYTIC BUILDING MATERIALS

Mejorar Eficiencia Fotocatalítica y Durabilidad

Modificar la estructura cristalina

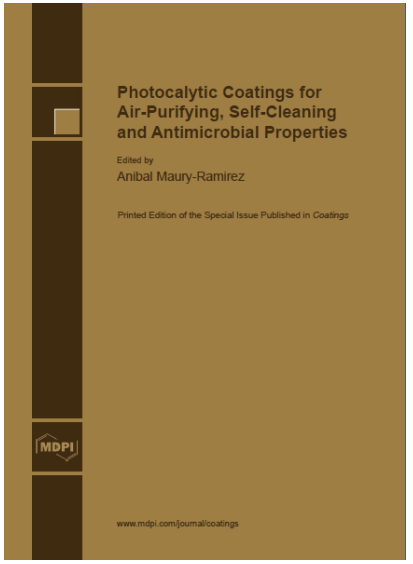
Introducir impurezas o estados defectuosos en la banda pohibida para permitir la absorción de luz visible (Maury-Ramirez, 2011).

Modificar el substrato

Incrementar la porosidad, rugosidad, acceso de luz del substrato y mejorar la adherencia en el caso de recubrimientos (Maury-Ramirez, 2011).

CHALLENGES IN THE APPLICATION OF PHOTOCATALYTIC BUILDING MATERIALS

Mejorar Eficiencia Fotocatalítica y Durabilidad



In this book, a wide variety of photocatalysts (TiO_2, Si-TiO_2, TiO_2−xNy, Ag-TiO_2, Mo-TiO_2, ZnO, SnO_2-Ag, Nb_2O_5 and C60 fullerene) were evaluated towards the removal of different molecules. Similarly, substrates such as glass, silica, sapphire, polycarbonate, aluminium, stainless steel, concrete and mortar were included.

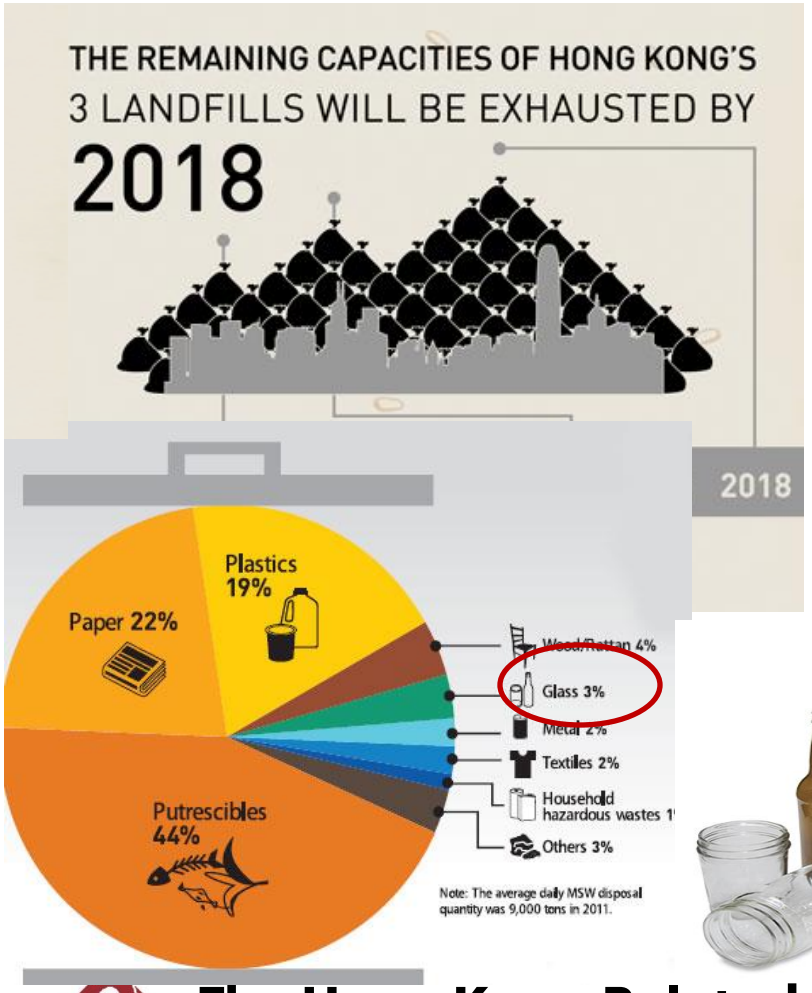
Anibal Maury-Ramirez (Editor). Special Issue from COATINGS on "Photocalytic Coatings for Air-Purifying, Self-Cleaning and Antimicrobial Properties", MDPI, Suiza, 2015 (1st Edition). ISSN: 2079-6412 and ISBN 978-3-03842-137-5 (PDF); 978-3-03842-138-2 (HBK).
http://www.mdpi.com/journal/coatings/special_issues/photocalytic-coatings

PROYECTO PILOTO: GREEN DECK (HONG KONG, CHINA)

IV

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Waste disposal problems in HK

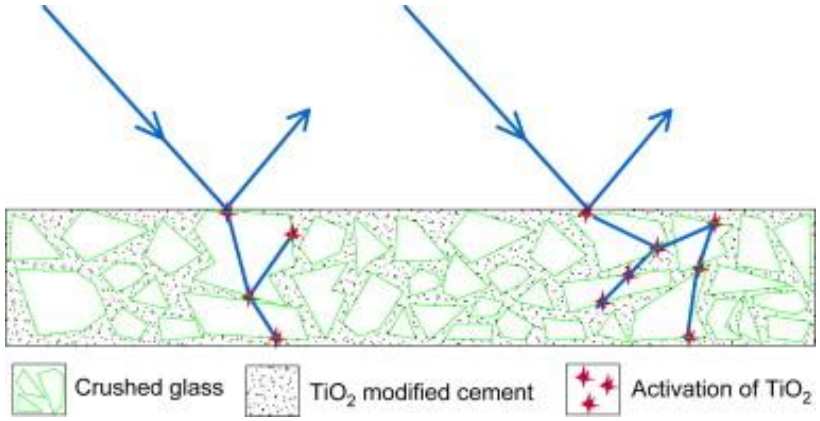


The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

Objective

Develop and characterize architectural mortars with enhanced air-purifying properties by the combined use of recycled glass as fine aggregate and TiO_2 as added catalyst



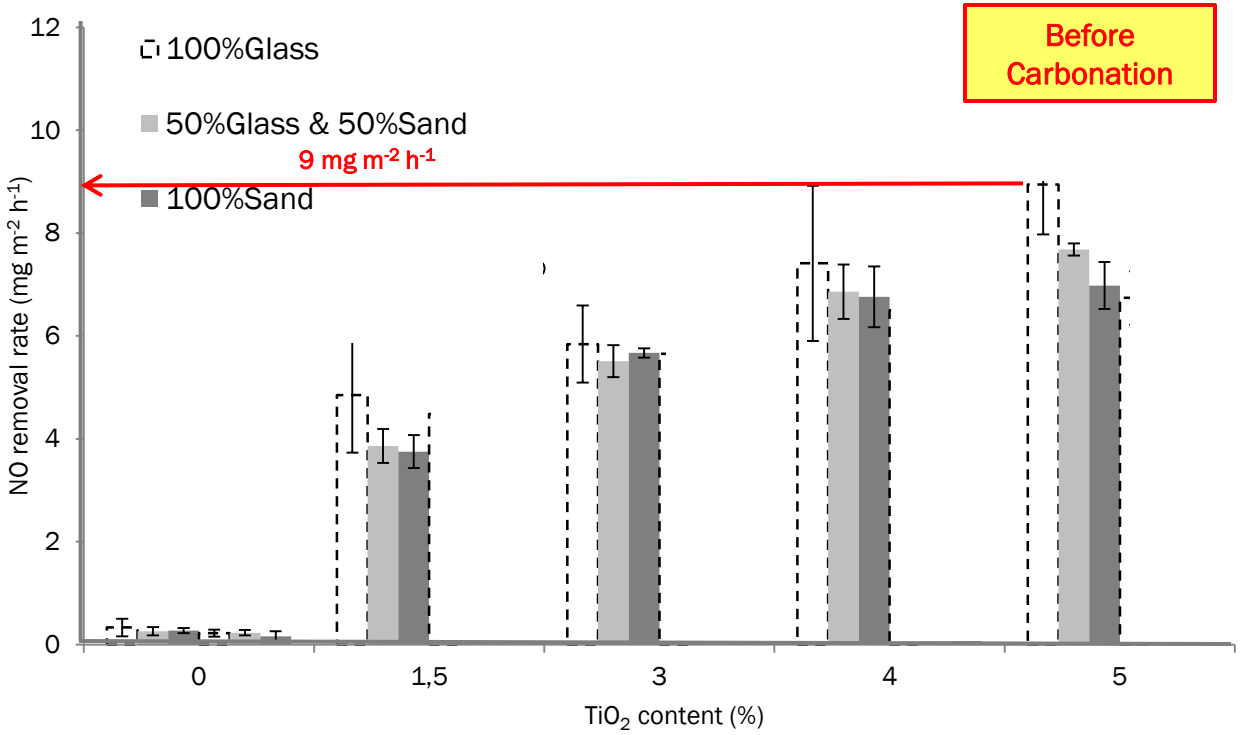
Chen and Poon (2009)

Pathways of light and activation of TiO_2 in concrete surface layer using glass as aggregates

The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

Results: Air-Purifying Potential

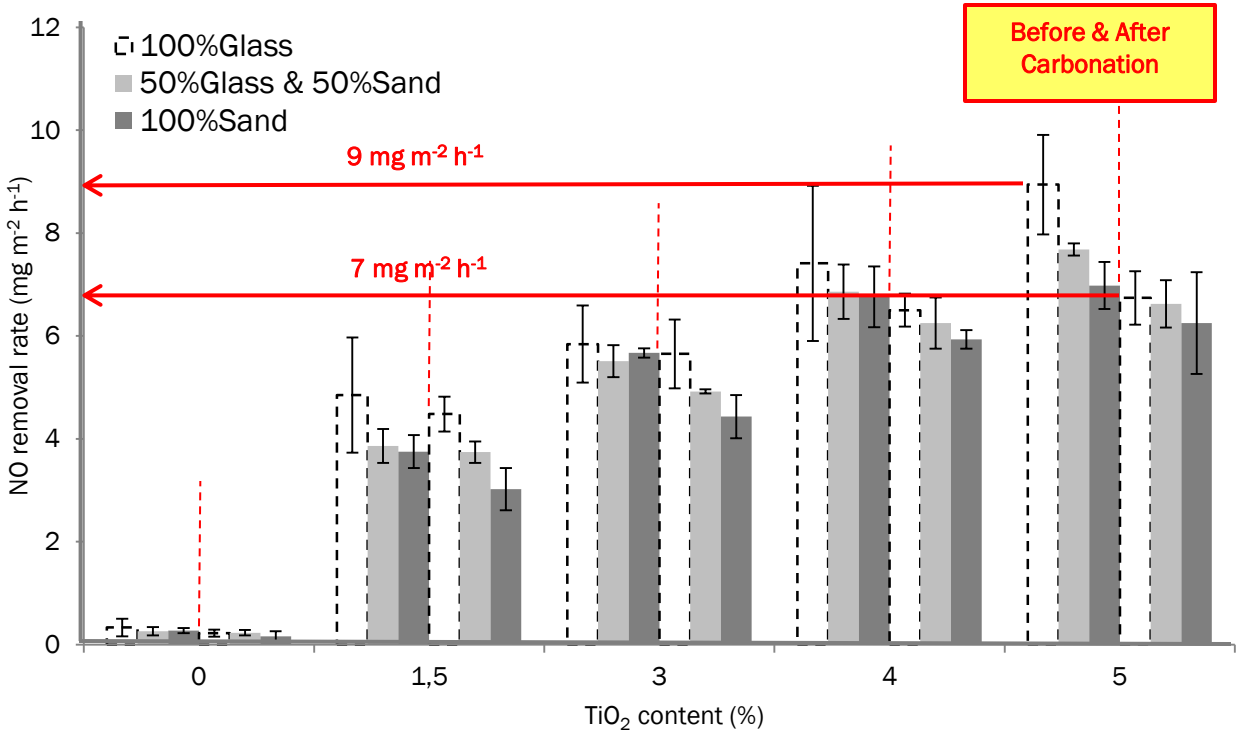


NO removal rates produced by different architectural mortars (before and after carbonation) containing TiO_2 (from 0 to 5%) and using recycled glass, recycled glass & sand, or sand as fine aggregate, respectively.

The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

Results: Air-Purifying Potential



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The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

Results: Air-Purifying Potential

NO removal rates and test conditions previously reported with cementitious materials using recycled glass as aggregate and TiO_2 as added catalyst

Material	Cement	TiO_2 concentration & (origin)	Recycled glass	Pollutant (Inlet conc. & flow)	Operating conditions	Elimination rates ($mg \cdot m^{-2} \cdot h^{-1}$)	Reference
concrete surface layers	OPC	2, 5 & 8% (Degussa P25)	transparent recycled glass	NO (1000 ppb, 6 $L \cdot min^{-1}$)	10% RH, UV-A	2-5.	Poon & Cheung (2006)
concrete surface layers	OPC	12.5% (Ke Xiang Chemical)	2 clear, light and dark green, brown	NO (1000 ppb, 3 $L \cdot min^{-1}$)	25 °C, 50% RH, UV-A (10 $W \cdot m^{-2}$)	1-3.	Chen & Poon (2009)
concrete surface layers	OPC	5 & 10% TiO_2 (Degussa P25)	-	NO (400 ppb, 3 $L \cdot min^{-1}$)	25 °C, 50% RH, UV-A (10 $W \cdot m^{-2}$)	3.7-4.1[(a)]	Chen et al. (2011)
self-compacting glass mortars	WC	2 & 5% TiO_2 (Degussa P25)	light green, transparent glass	NO (1000 ppb, 3 $L \cdot min^{-1}$)	25 °C, 50% RH, UV-A (10 $W \cdot m^{-2}$)	1.5-2.5.	Guo et al. (2012)
self-compacting glass mortars	WC	5% TiO_2 (Degussa P25)	light green	NO (1000 ppb, 3 $L \cdot min^{-1}$)	25 °C, 50% RH, UV-A (10 $W \cdot m^{-2}$)	2.5	Guo et al. (2013)

(a): 80-90 $\mu NOx mol \cdot m^{-2} \cdot h^{-1}$ are equivalent to 3.7-4.1 $mg NOx \cdot m^{-2} \cdot h^{-1}$

Results: Air-Purifying Potential

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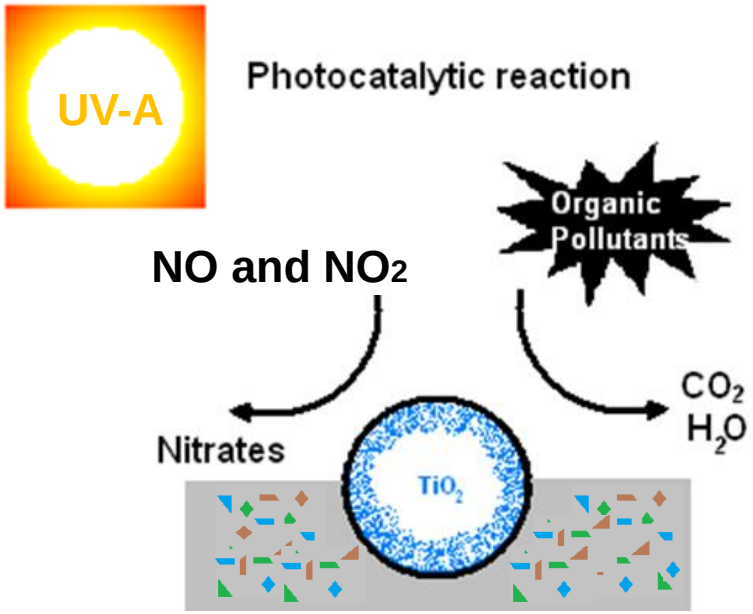
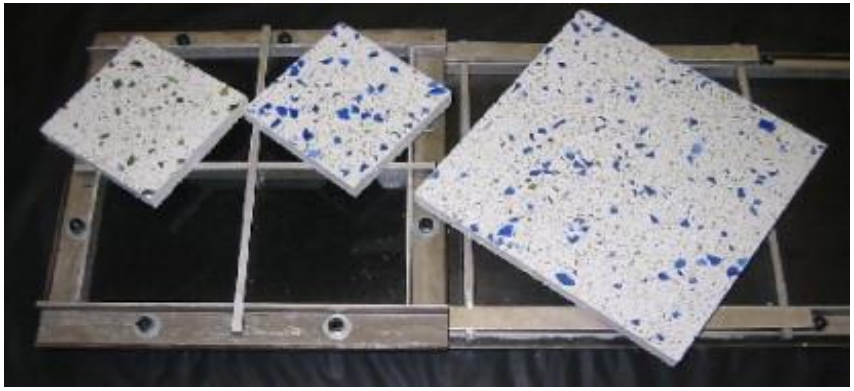
Eco-Architectural Mortar Containing Recycled Glass & TiO_2

Photocatalysis Fundamentals & Material Design



Eco-Architectural Mortar Containing Recycled Glass & TiO_2



Mix Proportion of Self-Compacting Architectural Mortar

0.8:0.2:2.0:0.4

white cement : MK : recycled glass : water

Approx. 143 tonnes of waste glass can be recycled as aggregate

The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

The Green Deck: Project Area

The Green Deck: Complete Project

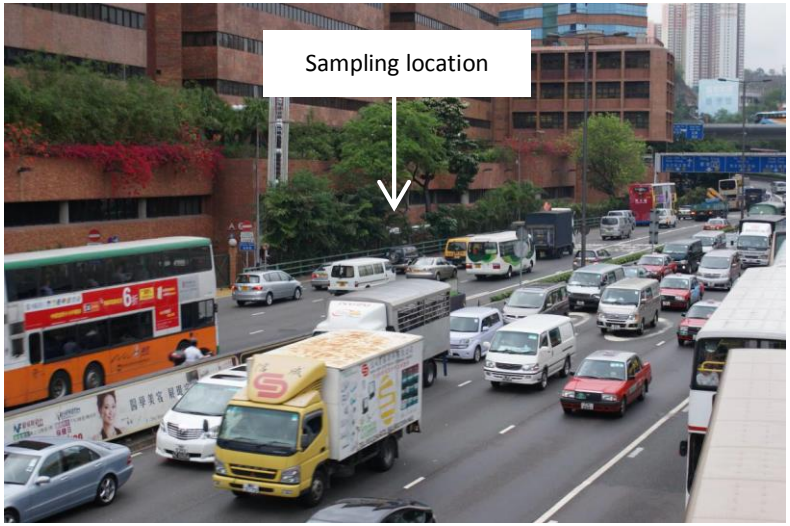
Green Deck as an Innovative Social Project

an innovative solution to problems in Cross Harbour Tunnel vicinity

The Green Deck: Research Findings

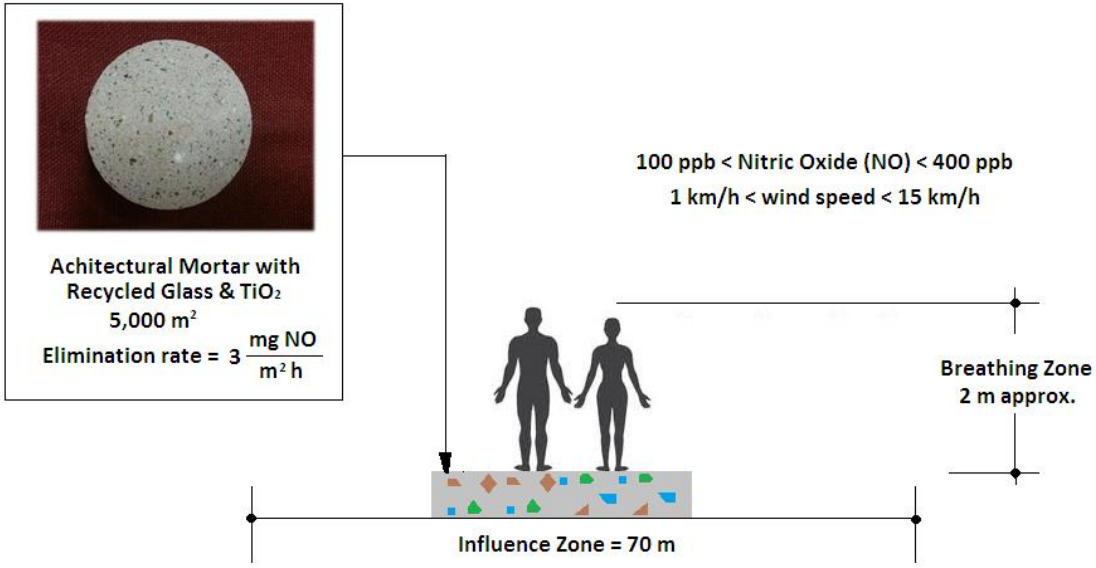
In-situ Evaluation - NO_x removal – (Running Tests)

Accumulated nitrite (NO_2^-) and nitrate (NO_3^-) will be monitored on architectural mortars placed on an internal PolyU road during 3 months. Gaseous NO_x removed by the photocatalytic reactions on the samples should be oxidized to NO_2^- and NO_3^-. The concentrations of nitrate and nitrite ions obtained from the sample elutions will be measured by ion chromatography (DX500, Dionex).



Internal PolyU campus road next to the Kowloon entrance to the Hong Kong Harbor Tunnel

Est. Impact of The Green Deck



A Nitric Oxide (NO) removal efficiency ranging from 0 to 86%, depending on the wind velocity, is estimated for the "Green Deck"

Approx. 143 tonnes of waste glass can be recycled as aggregate by the construction of the "Green Deck"

The Hong Kong Polytechnic University

Department of Civil and Environmental Engineering

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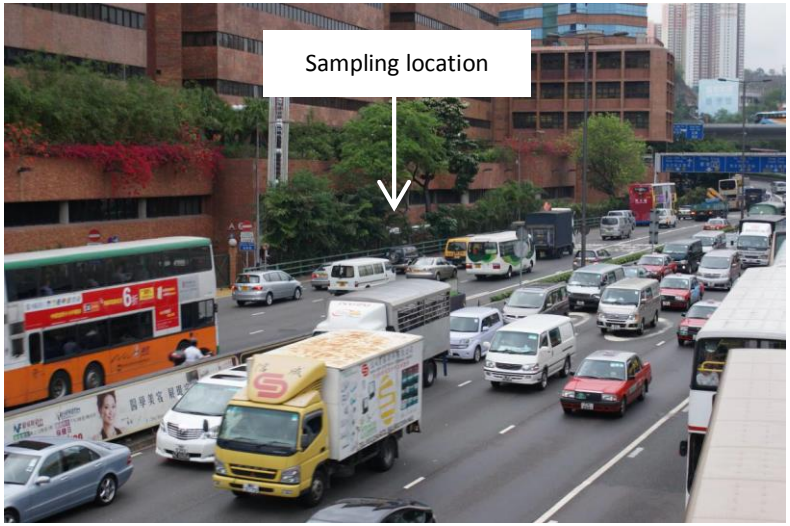
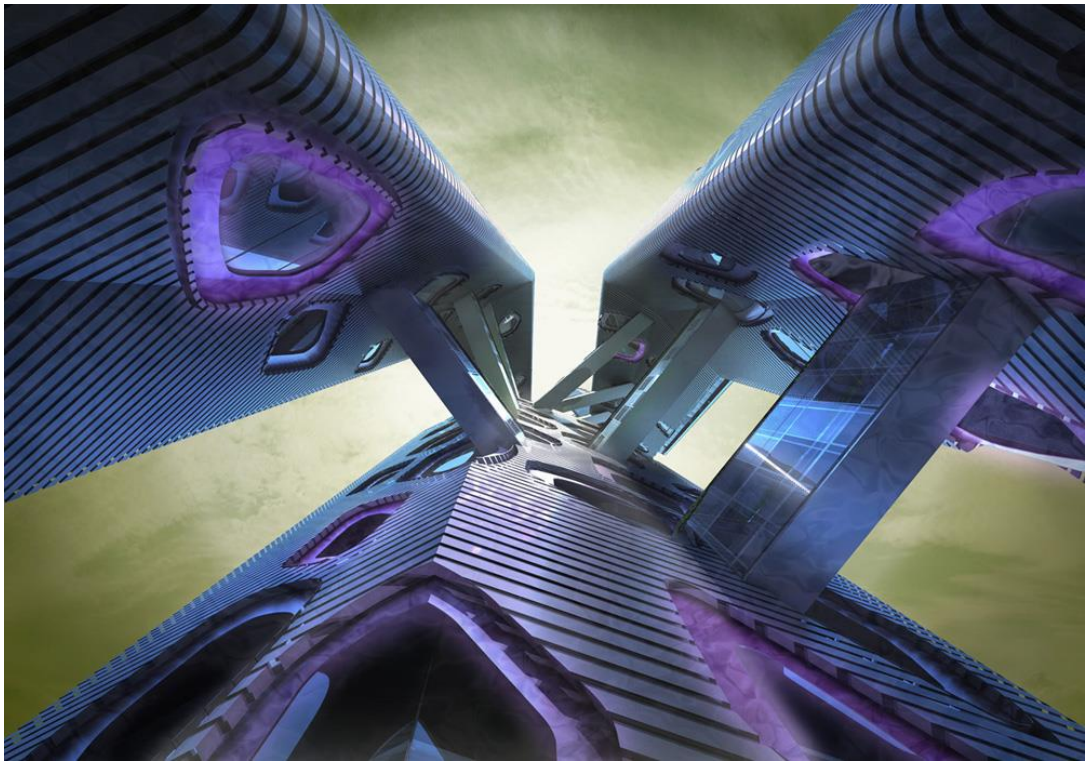


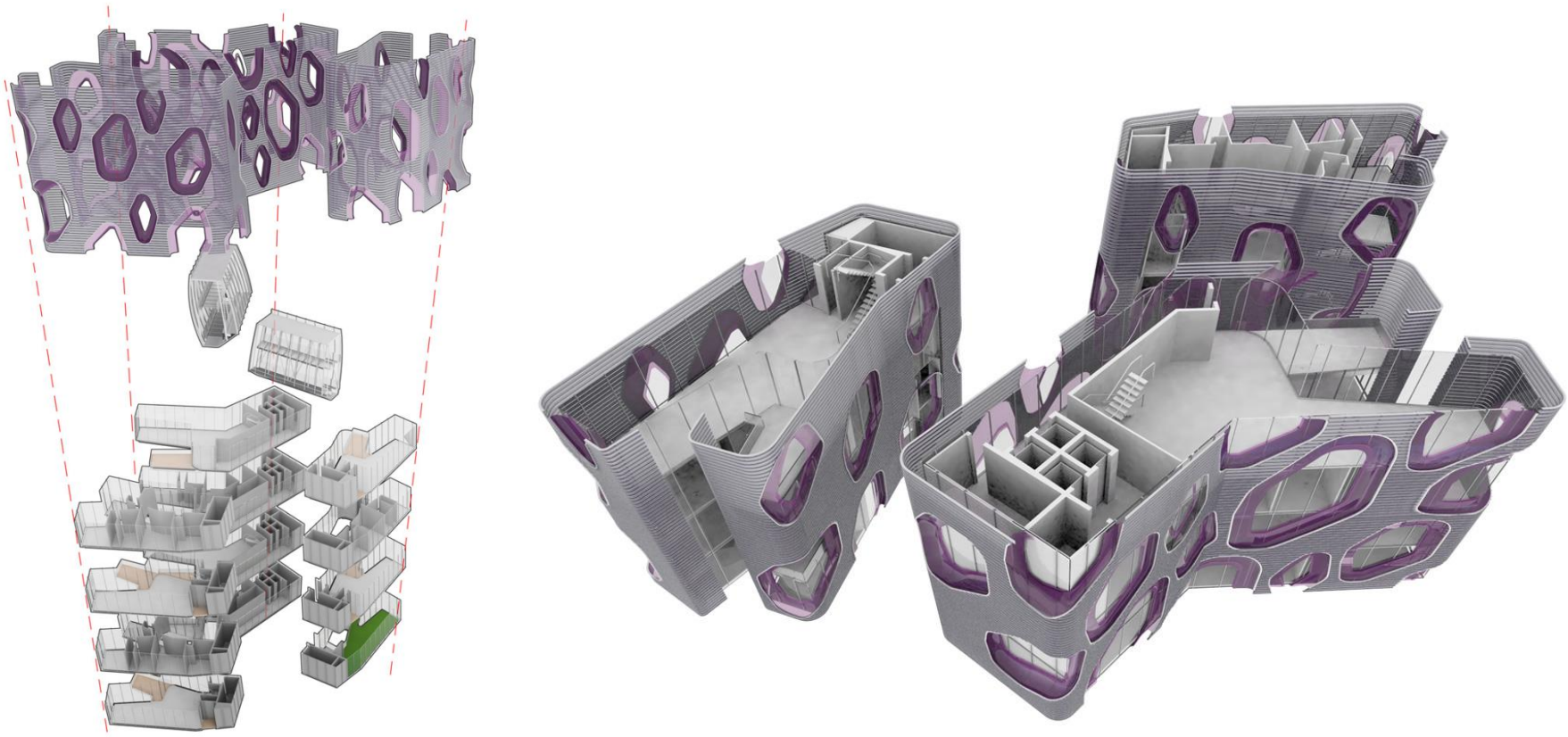
Internal PolyU campus road next to the Kowloon entrance to the Hong Kong Harbor Tunnel

Future trends in Hong Kong



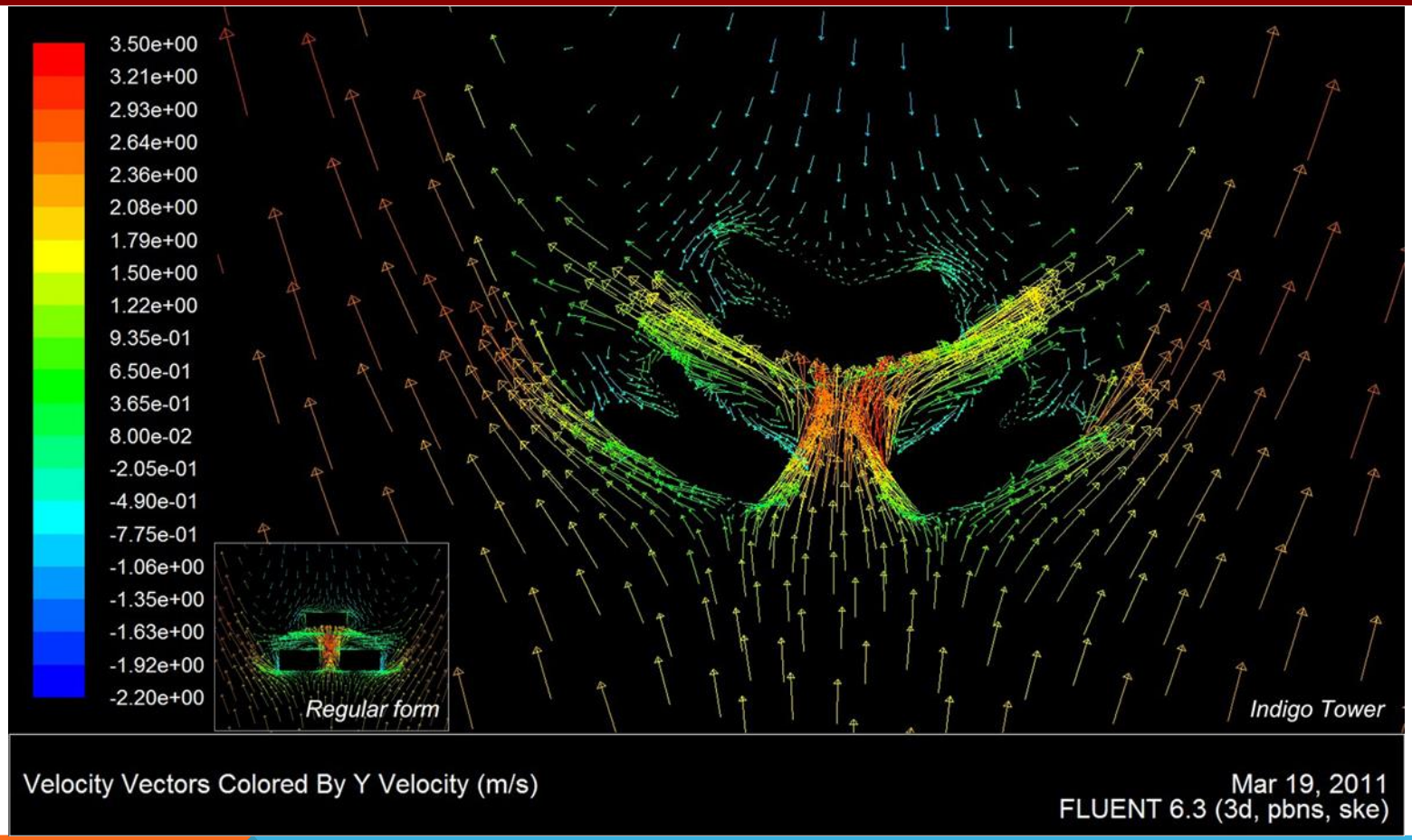
INDIGO TOWER (10Design - Hong Kong)

Future trends in Hong Kong



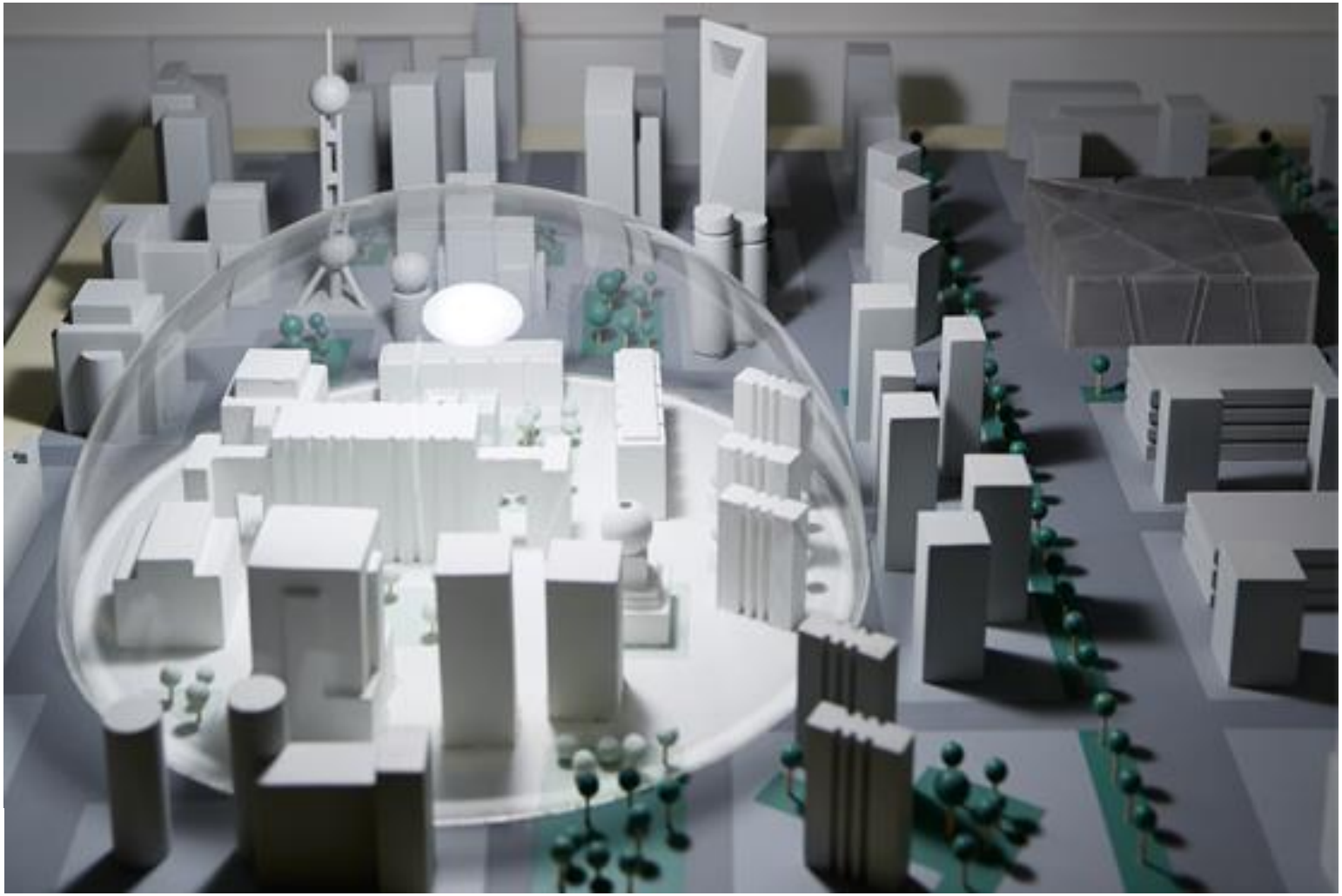
INDIGO TOWER (10Design - Hong Kong)

Future trends in Hong Kong



Air Quality Improvement in HK

Modelo a Escala Urbana con TiO_2 – Milan (Italia)



Italcementi
HEIDELBERGCEMENT Group

PROYECTO PILOTO: TÚNEL AV. COLOMBIA (CALI, COLOMBIA)

V

Medina A, Torres D., Meza G., Villota R. & Maury A. (2016)

Objetivos

Diseño de un sistema de purificación del aire y auto-limpieza en las superficies del túnel de la Av. Colombia (Cali) con base en la remoción de colorantes indicadores (azul de metileno y rodamina b).

Túnel y Bulevar Avenida Colombia (Cali)

Metodología

Reactor Para Remoción Fotocatalítca de Colorantes

Azul de Metileno y Rodamina B - Colorantes

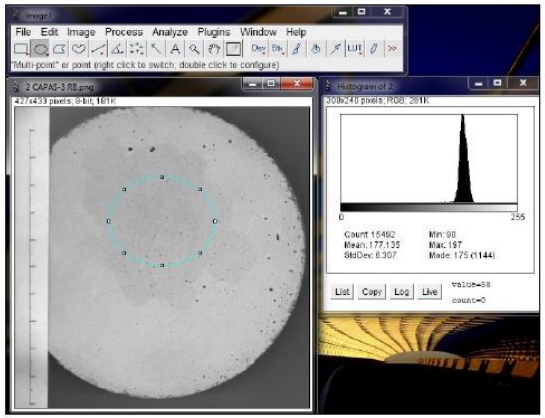


Figura 54. Medición del valor de intensidad en la escala de grises de la zona contaminada con rodamina b de la muestra 2 CAPAS-3 RB

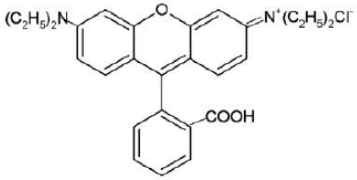


Figura 47. Estructura molecular de la Rodamina B. Fuente: Tesis Ulises Matías

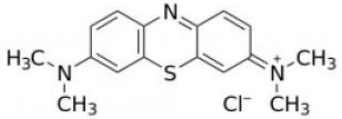


Figura 48. Estructura molecular del azul de Metileno. Fuente: Tesis Ulises Matías

Resultados

Aplicación de los colorantes sobre muestras

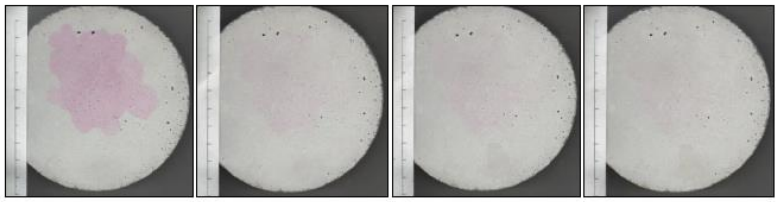


Figura 51. Seguimiento de la muestra 2 CAPAS-3 RB en las edades de 0, 4, 8 y 24 horas

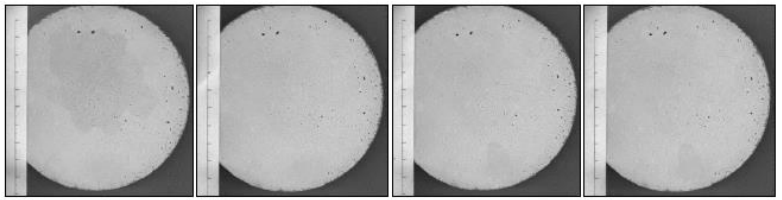
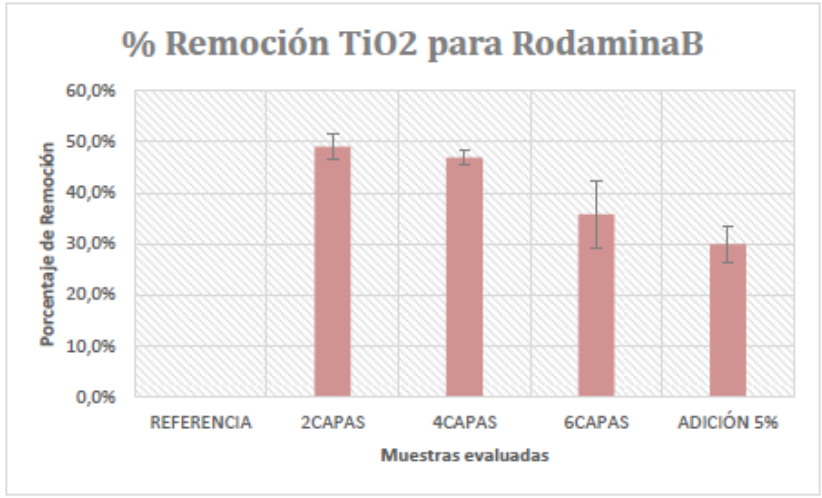
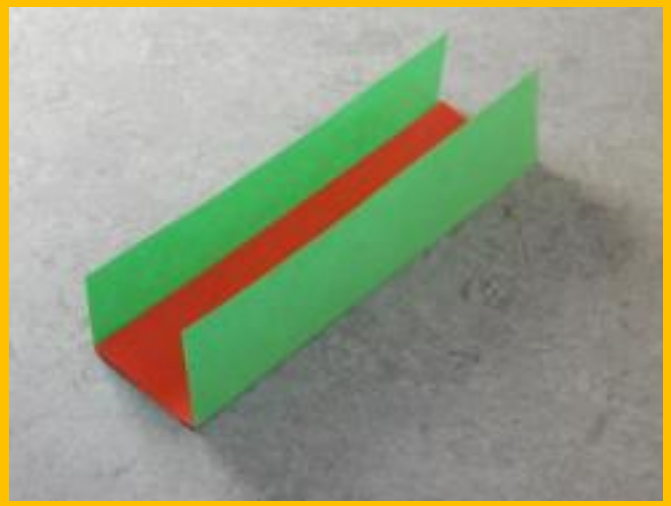


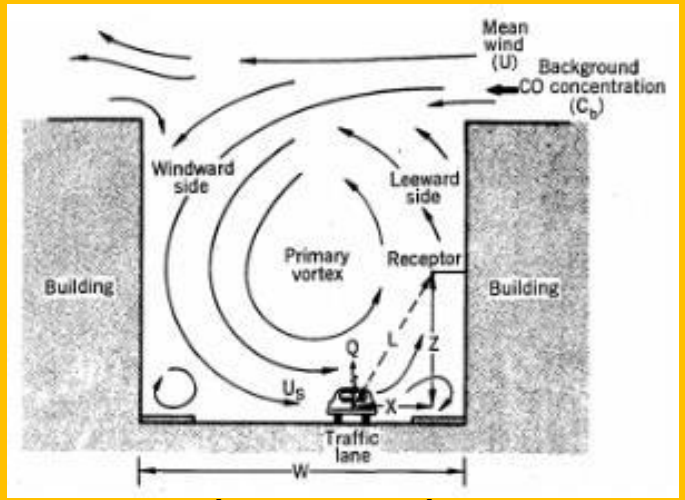
Figura 52. Muestras 2 CAPAS-3 RB en las edades de 0, 4, 8 y 24 horas en formato 8-bit del software ImageJ



Resultados



Representación de un Street Canyon. Fuente: winOSPM software, Dinamarca



Representación esquemática del modelo presentado por Korc

Parámetros de entrada. NOx	
N	5000 veh/h
q	0,25 g/km/veh
u	2,00 m/s
W	3,00 m
x	1,43 m
z	2,25 m
K	7
t	1 h

Óxidos de Nitrógeno	
C1 Sotavento	208 µg/m3
C1 Barlovento	324 µg/m3
C1 Paralelo a la calle	266 µg/m3

$$Sotavento \quad C_1 = \frac{\frac{K * N * q}{3,6}}{(u + 0,5) * [(x^2 + z^2)^{\frac{1}{2}} + 2]}$$

$$Barlovento \quad C_1 = \frac{\frac{K * N * q}{3,6}}{W * (u + 0,5)}$$

$$C = \left(\frac{1}{2}\right) * [C_1(Barlovento) + C_1(Sotavento)$$

Resultados

AIR-PURIFYING AND SELF-CLEANING URBAN INFRASTRUCTURE USING SUNLIGHT

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