

Evaluation of Human Health Risk due to Benzene Exposure in Japan

日本全体を対象にしたベンゼンの健康リスク評価

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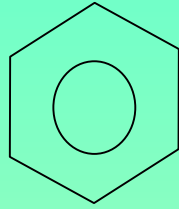
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Content 目次

- What is Benzene ベンゼンとは
- Source of Benzene emission ベンゼンの排出源、自動車排気ガス
- NO_xから推測できるのでは
- リスクアセスメント
 - モニタリング
 - 地図
 - 方法(装置)
 - モニタリング結果
 - 今日のベンゼン
 - No_xとの挙動同じ
 - 風速
 - 相関式の決定
 - 暴露アセスメント
 - 暴露アセスメント手法
 - 暴露濃度人口分布の図
 - リスク分布(東京、岩手がどう相当するか等)
- リスクマネジメント
 - 従来の手法による対策(ガソリン規制、環境庁)
 - 我々の案と環境庁の案の違い(表)
 - ベンゼン問題に対するマネジメントについての一案

Benzene



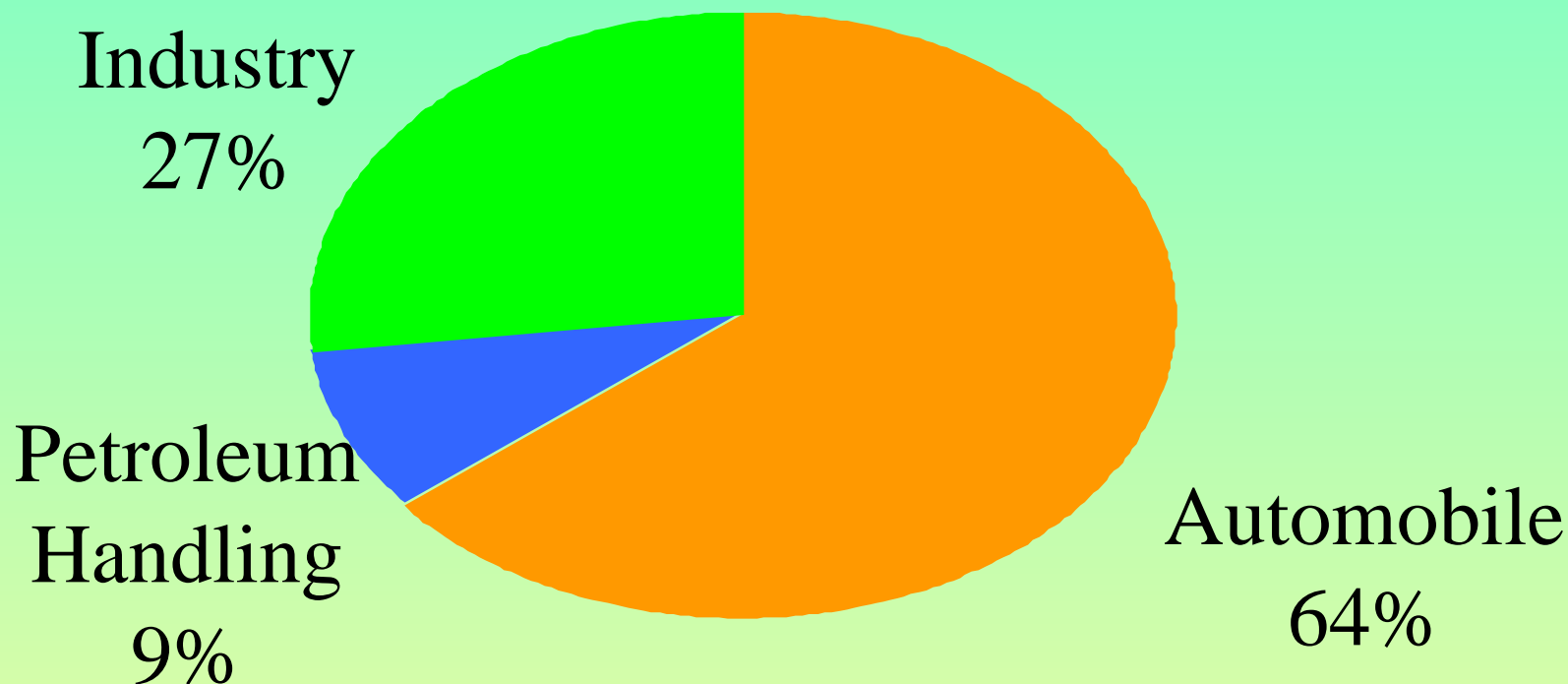
- causes Myelogenous Leukemia. (白血病)
- classified as a Group A human carcinogen by EPA
- has the highest cancer risk among the air pollutants.
- included in gasoline and automobile exhaust gas.

Benzene causes cancer

ベンゼンは人に対し骨髄性白血病を起こさせる発ガン性物質。
ガソリンや自動車排気ガス中に含まれる。

Source of Benzene Emissions (Japan '95)

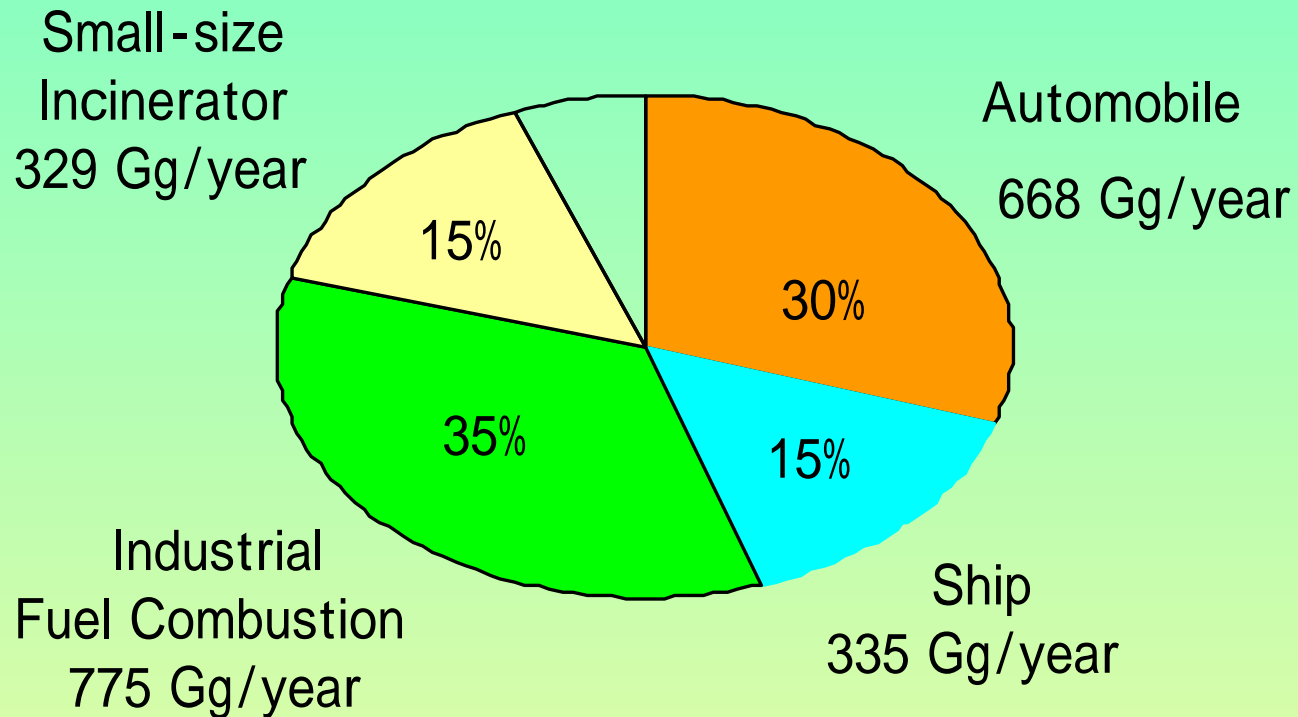
ベンゼンの排出源



Main source of benzene emission is Automobile

Source of NOx Emissions (Japan '95)

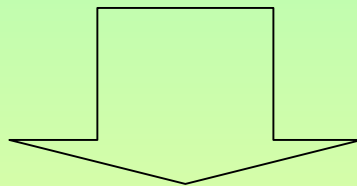
NOx の排出源



Main source of NOx emission is Automobile too.

How can we estimate the population risk from benzene ?

- Main source of both Benzene and NO_x emissions are from Automobile.
- At present, benzene level is not routinely monitored nationwide in Japan.
- NO_x levels are routinely monitored at 1819 monitoring stations nationwide.



[Assumption]

Benzene levels can be estimated using NO_x data.

<Basic Procedure>

Organization of NO_x data throughout Japan

↓
No_x levels are monitored and recorded at 1443 general air pollution monitoring (GAP) stations and 376 automobile exhaust (AE) monitoring stations nationwide.
The yearly mean levels of NO_x at all stations in 1994 are used for the further analysis.

Exposure Analysis of NO_x

Regression of the relationship between NO_x level and benzene level

↓
Both No_x and benzene levels were determined by monitoring in some places.

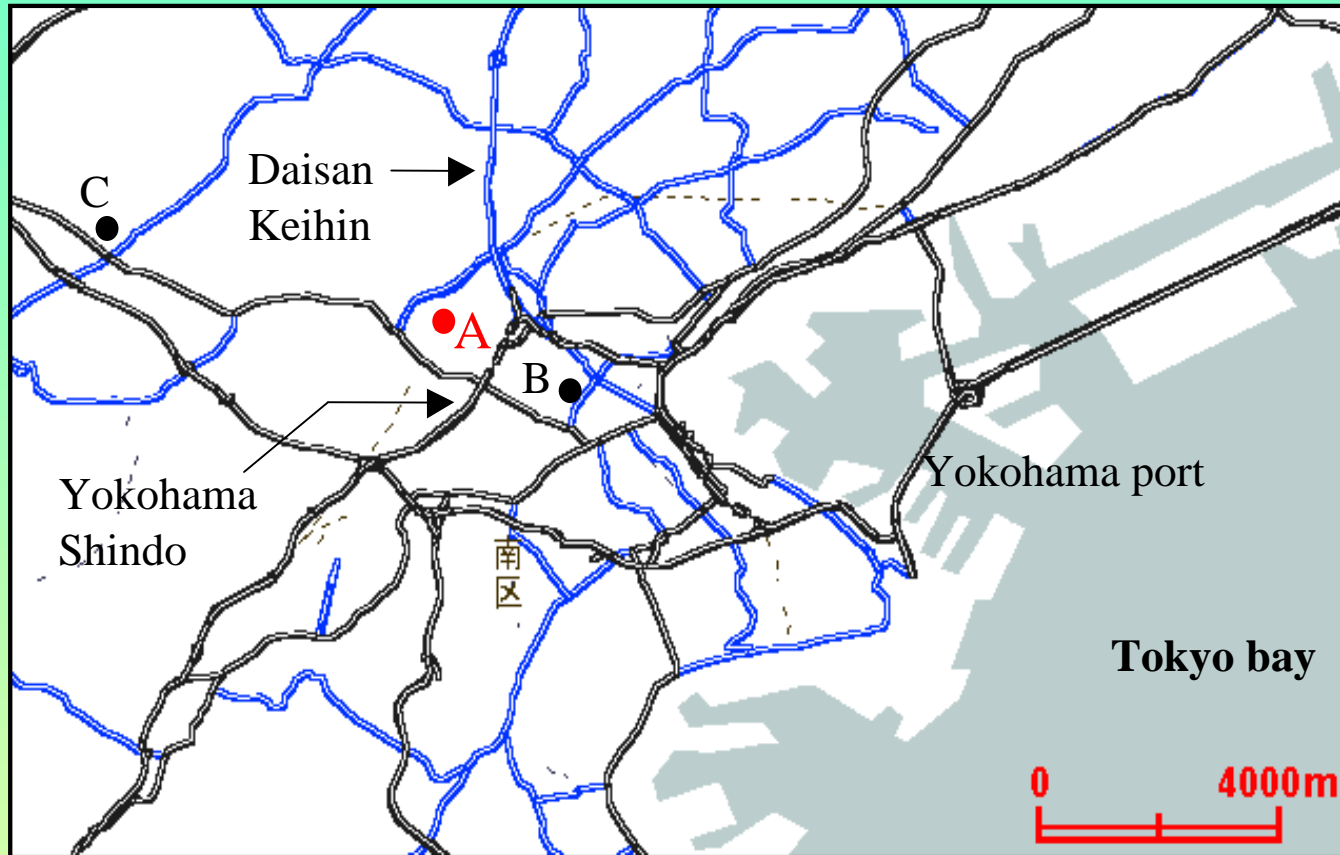
Estimation of population exposed to benzene

Evaluation of cancer risk of the total population in Japan

↓
Unit risk of $8.1 \times 10^{-6} \mu\text{g}^{-1} \text{m}^3$ was used.

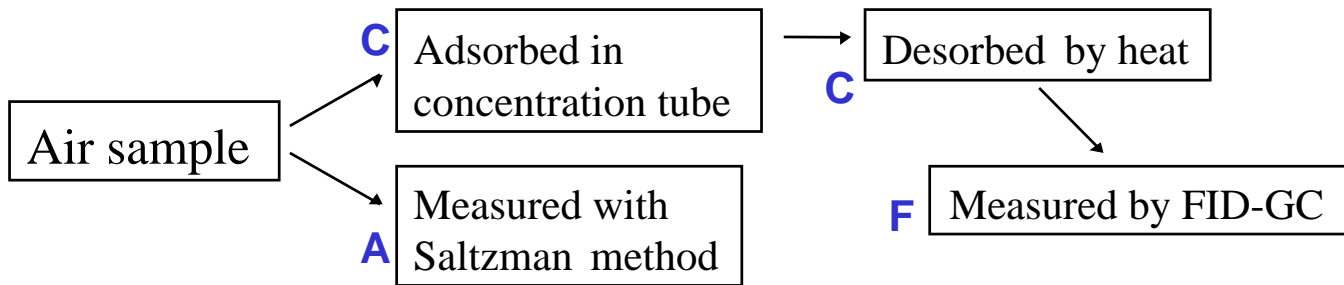
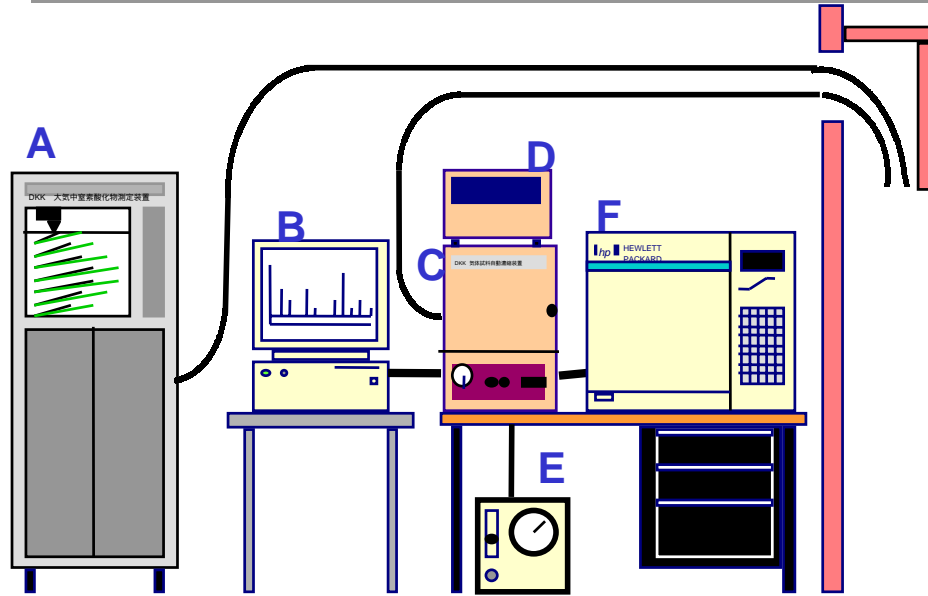
Estimation of the effects of reducing benzene levels in Gasoline

A Map of Sampling Points in Yokohama



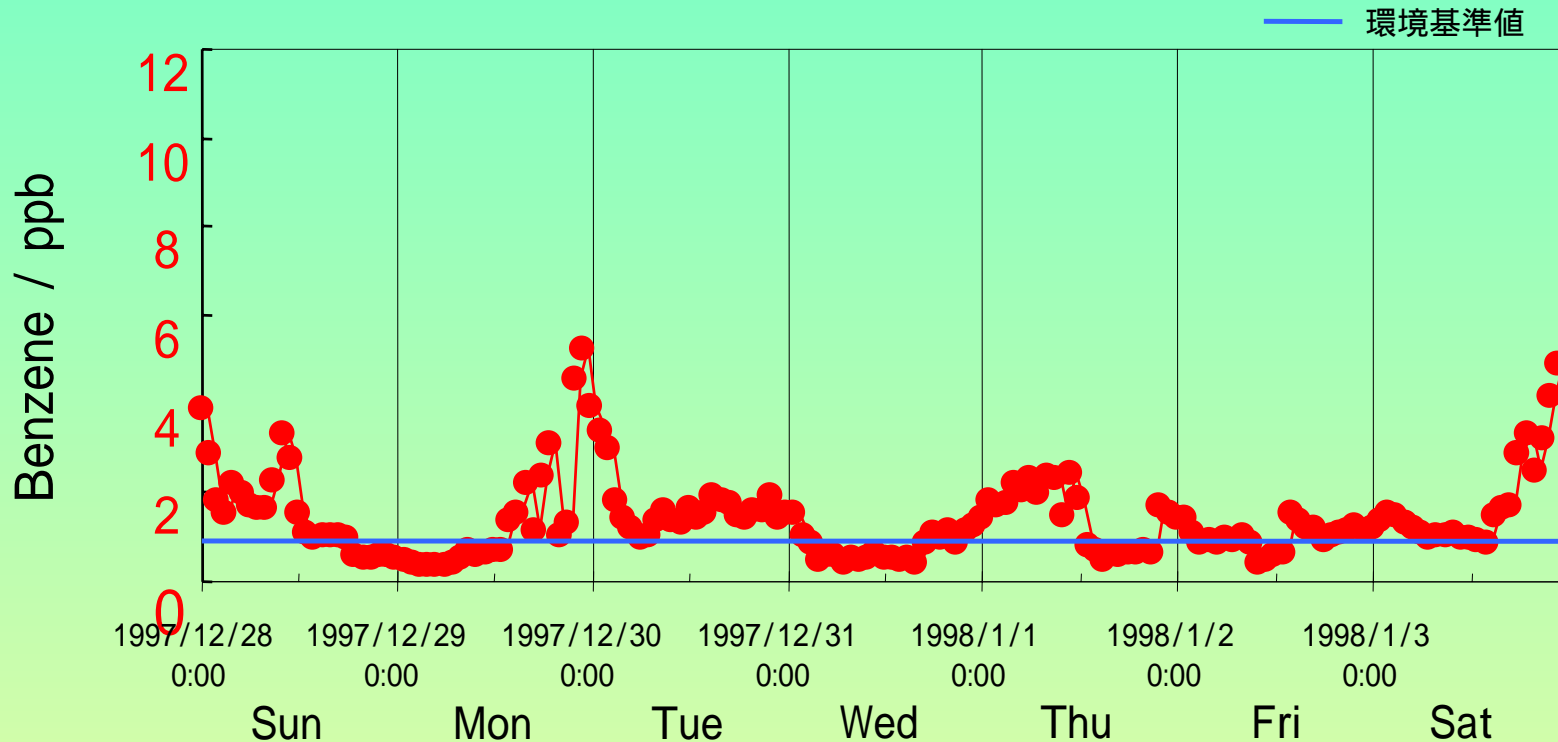
- A: Yokohama National University (YNU)
- B: Sengenshita Crossing
- C: Tsuoka Crossing

System for monitoring of ambient levels of benzene and NOx.

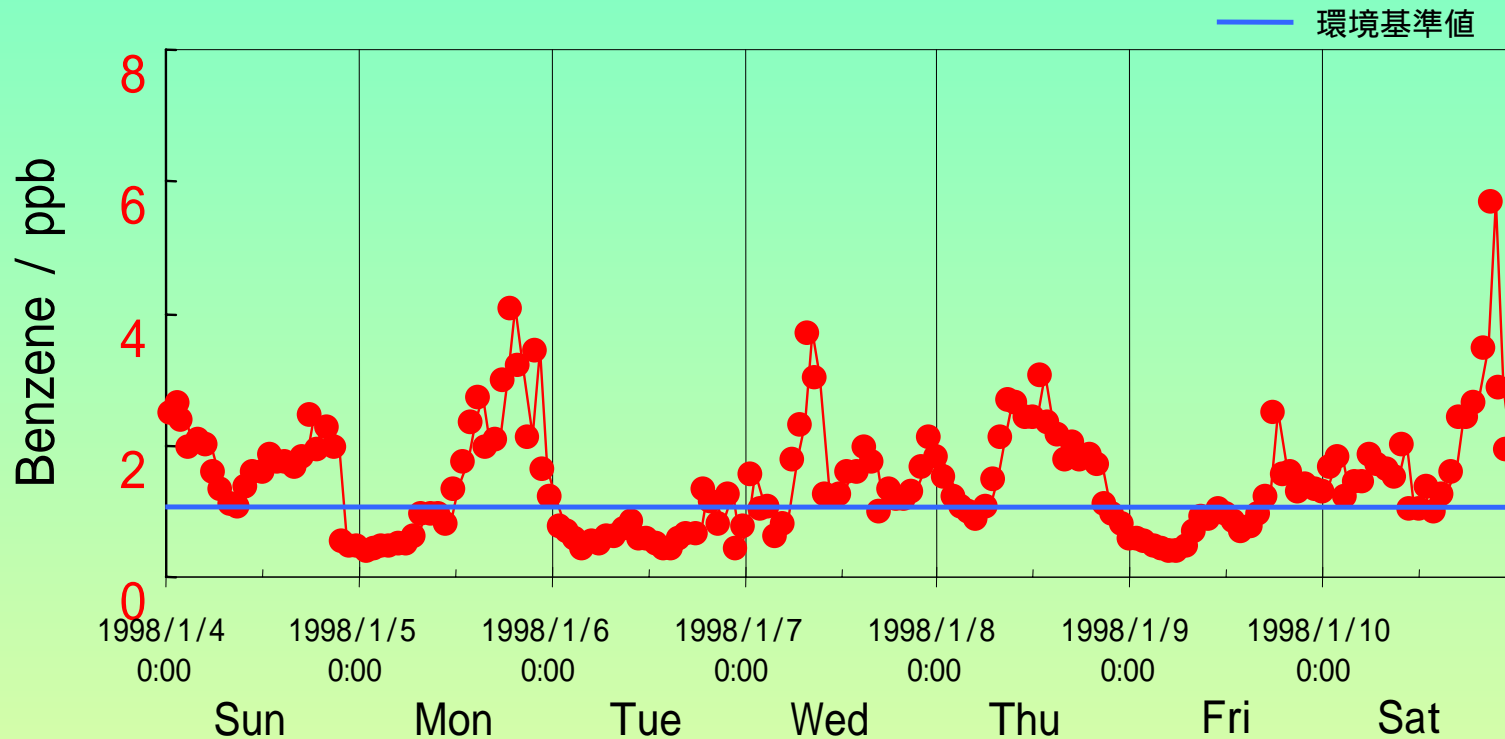


Hourly concentrations of Benzene at Yokohama National University 横浜国大におけるベンゼン濃度の1週間の時間変化

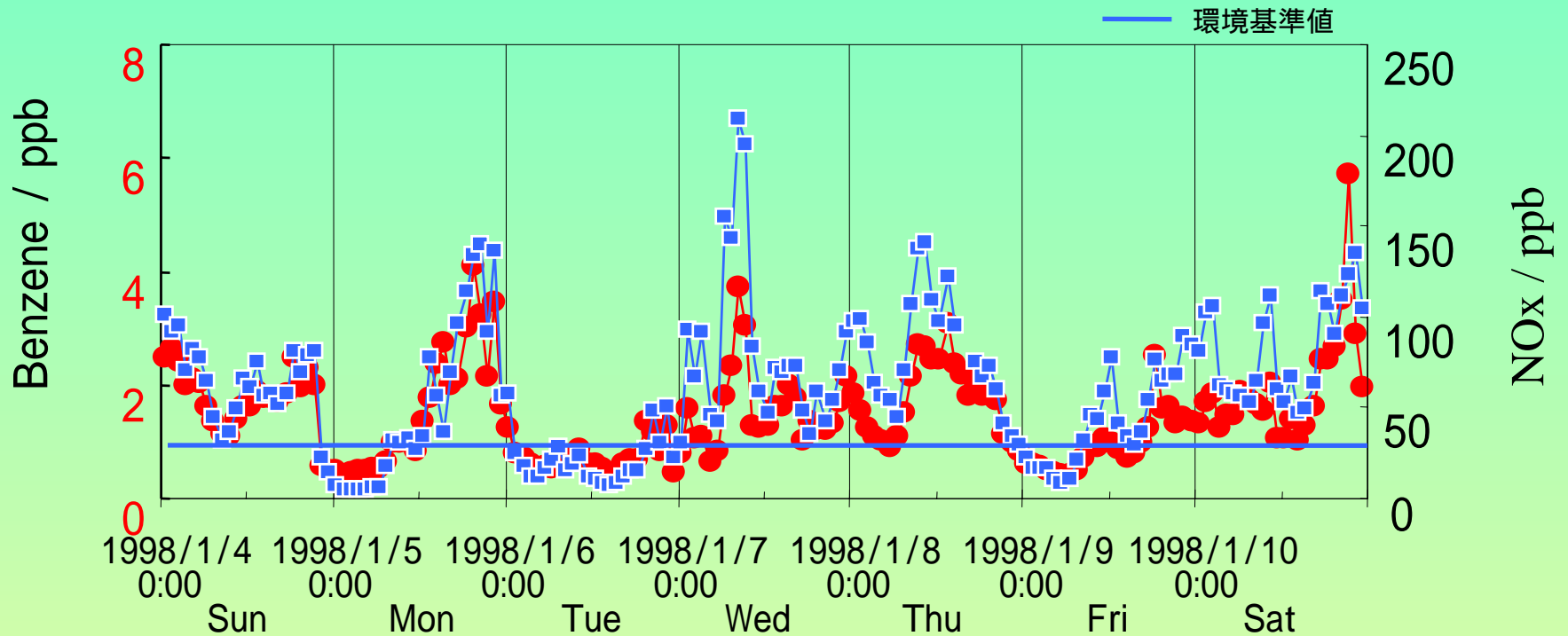
Environmental Quality Standard



Hourly concentrations of Benzene at Yokohama National University 横浜国大におけるベンゼン濃度の1週間の時間変化

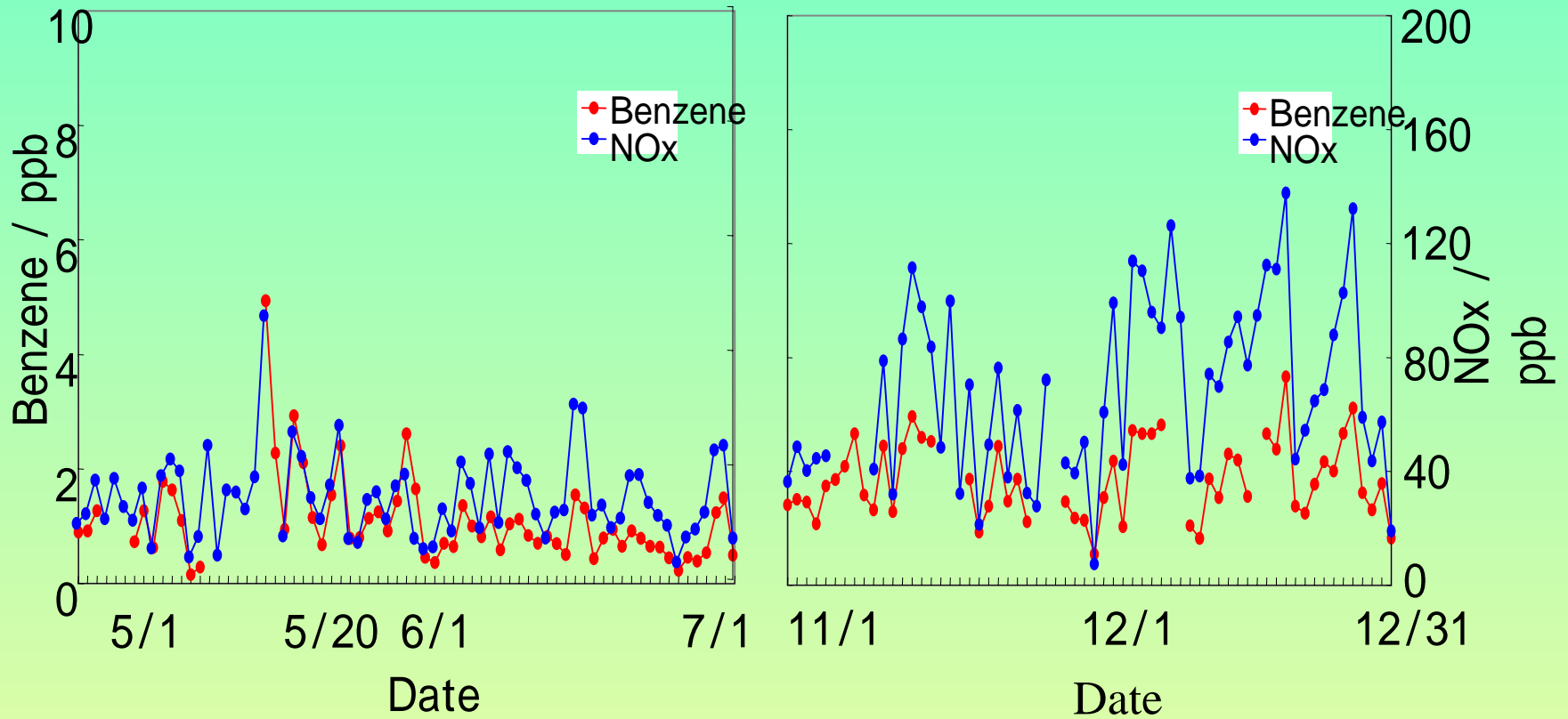


Hourly concentrations of Benzene and Nox at Yokohama National University 横浜国大におけるベンゼンとNOxの1週間の時間変化



Benzene and NOx levels are highly correlated
ベンゼンとNOxの濃度が高い相関を示していることがわかる

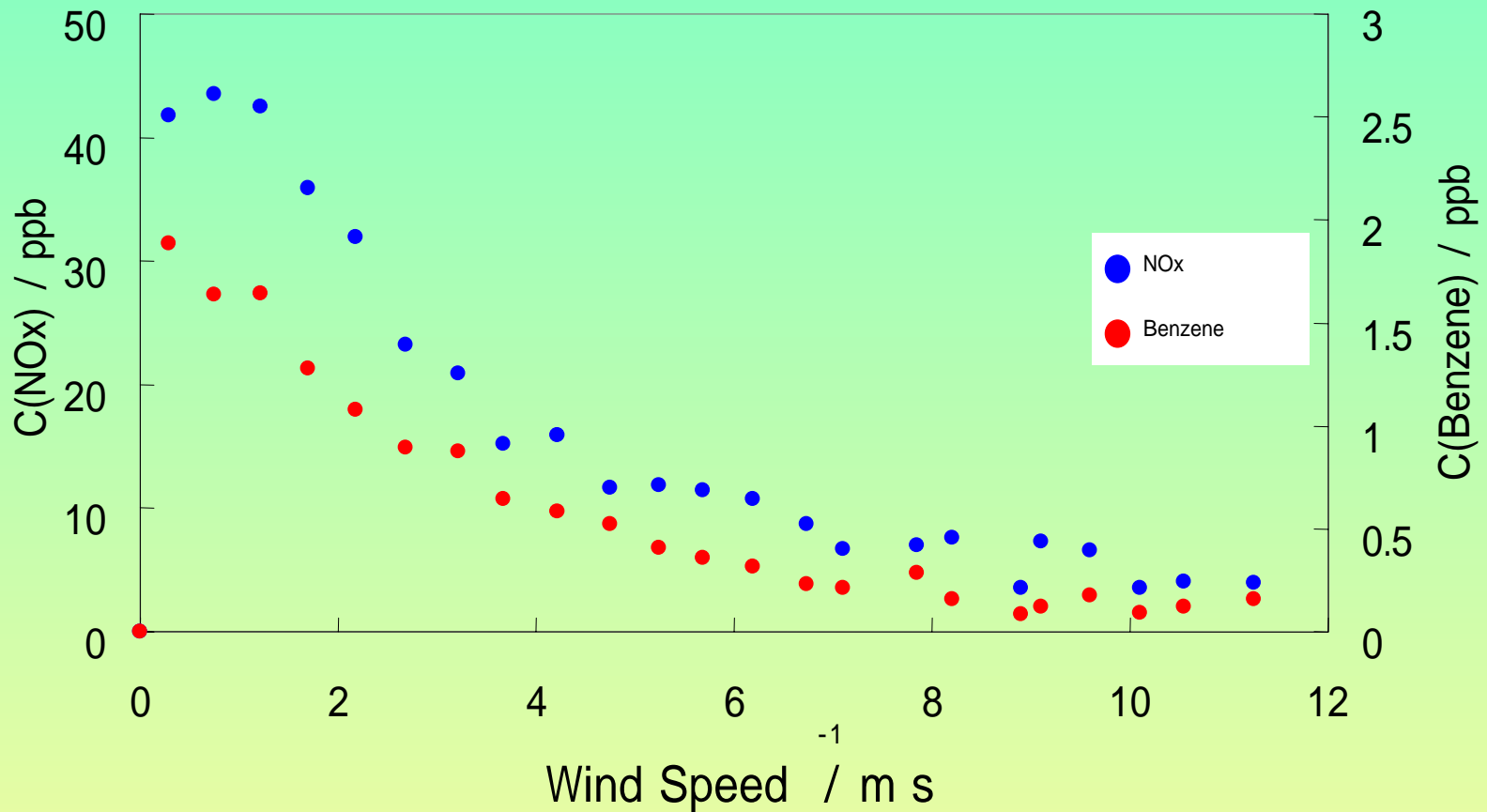
Dayly concentrations of Benzene and NO_x at Yokohama National University



Both NO_x and Benzene levels are higher in winter than in summer

The relation between wind speed and NO_x, Benzene levels

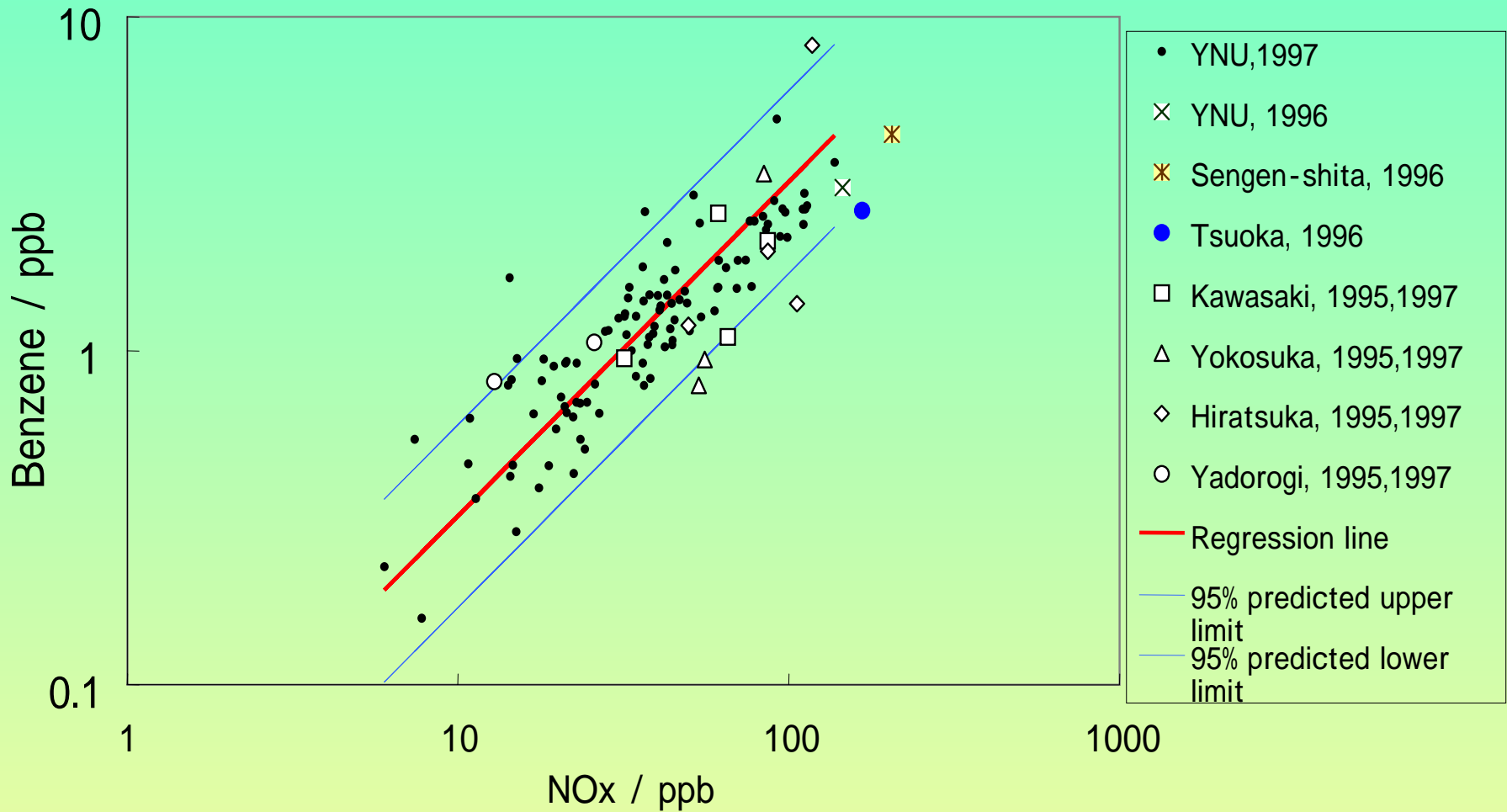
NO_x,ベンゼン濃度と風速との関係



Both Benzene and NO_x levels decrease with increasing wind speed

Correlation between Benzene and NOx levels

ベンゼン濃度とNOx濃度との相関



$$[\text{Benzene}] = 0.036 [\text{NO}_x]$$

Classification For estimating the distribution of population

) **URBAN** : defined as municipality which has both GAP monitoring stations and AE monitoring stations.

80% of the population lived in the municipality are exposed to benzene in the levels at GAP monitoring stations, and 20% of the population are exposed to levels at AE monitoring stations.

) **SUBURB** : defined as municipality which has GAP monitoring stations only.

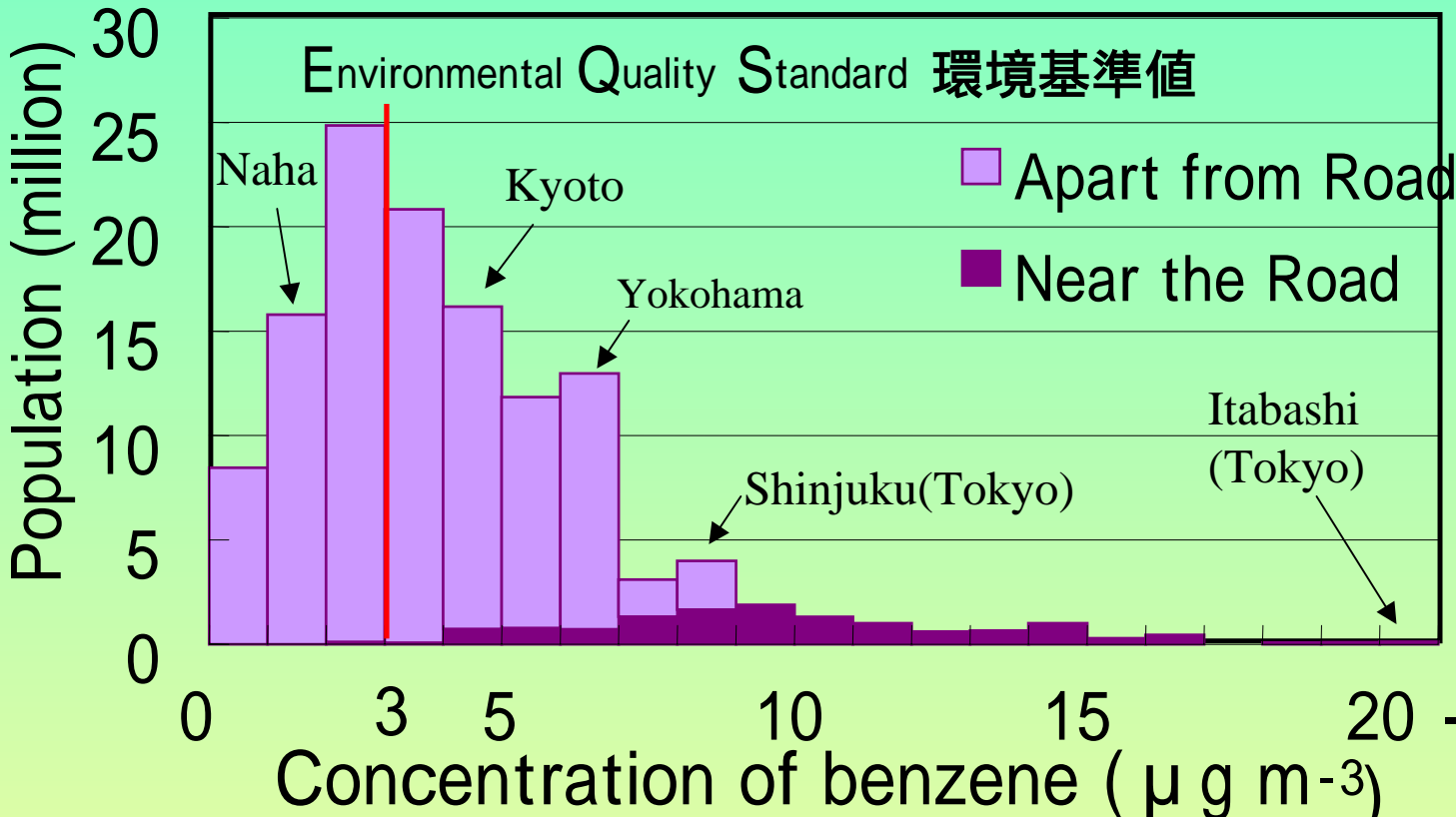
All the population lived in the municipality are exposed to benzene in the levels at the GAP monitoring stations.

) **RURAL** : defined as municipality which has no monitoring stations.

All the population lived in the municipality are exposed to benzene in the level at the GAP monitoring stations close to the municipalities.

(GAP : General Air Pollution, AE : Automobile Exhaust)

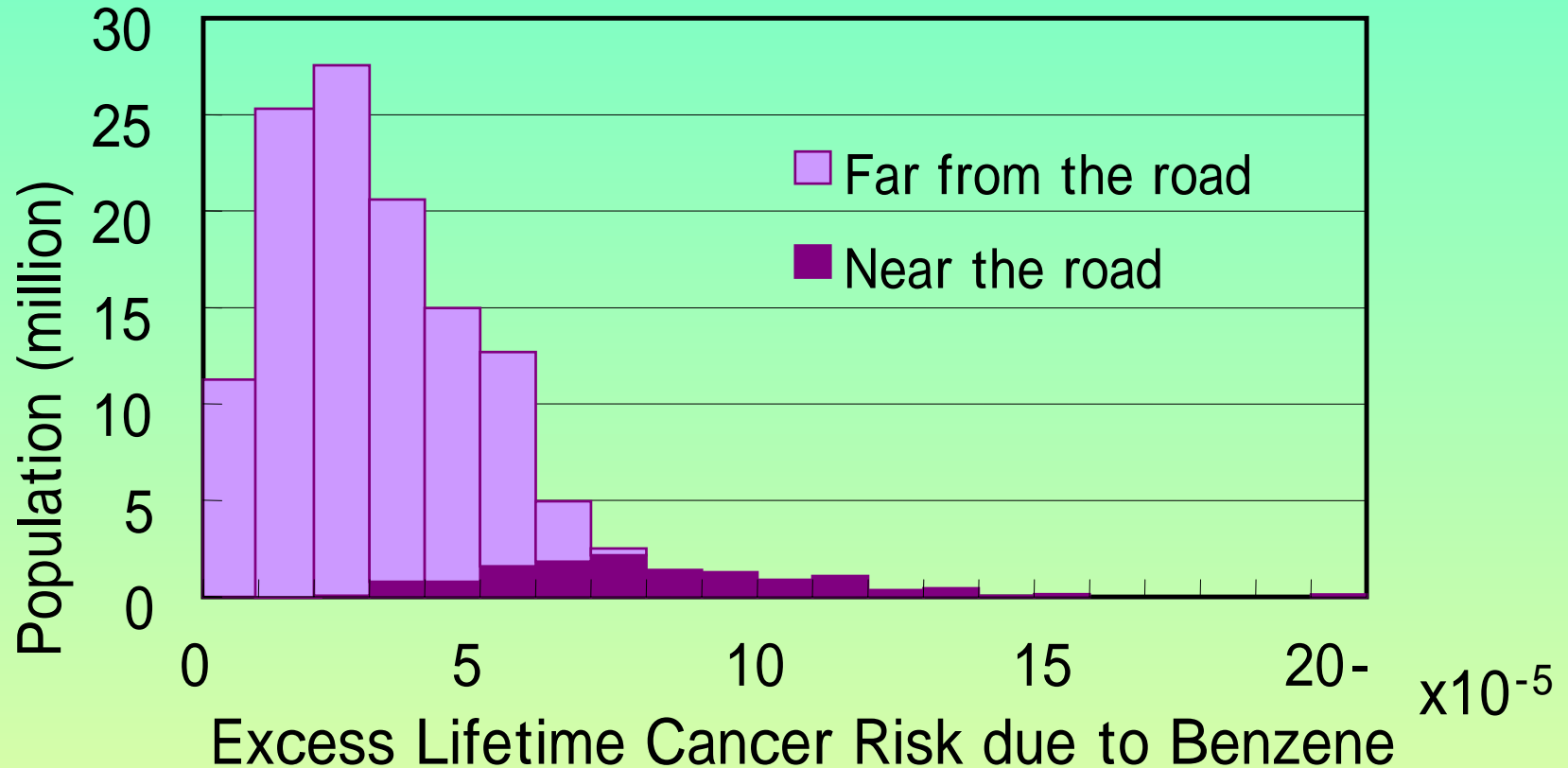
Distribution of population vs. concentration of ambient Benzene in Japan (日本における大気中ベンゼン濃度に対する人口分布)



The arithmetic average of exposure concentration is $4.3 \mu\text{g m}^{-3}$.
 About **60%** of the total population is exposed to the level above the EQS level.

Excess Lifetime Cancer Risk
= (Exposure concentration) x (Unit Risk)

Distribution of population vs. cancer risk of ambient Benzene in Japan (日本における大気中ベンゼンの発ガンリスクに対する人口分布)



Annual cancer death due to exposure to ambient benzene in Japan is estimated to be **62** cases

(日本における大気中ベンゼンによる年間発ガン死亡数は62人と見積もられる)

Summary of Risk Assessment

アセスメントのまとめ

- Benzene levels are highly correlated to NO_x levels.
 - 大気中ベンゼン濃度とNO_x濃度との間には高い相関がある。
- Correlation ; [Benzene] = 0.036 [NO_x] was yielded.
 - 相関式として[Benzene] = 0.036 [NO_x]が得られた。
- The average of personal exposure levels in Japan is 4.3 μg m⁻³.
 - 日本における大気中ベンゼンの個人暴露濃度の平均は3.4 μg m⁻³。
- The average of excess cancer risk for lifetime in Japan is 3.4 x 10⁻⁵.
 - 日本における大気中ベンゼンによる過剰発ガンリスクの平均は3.4x10⁻⁵。
- Annual cancer death due to benzene in Japan was estimated to be 62 cases.
 - 1年に62人がベンゼンによってガン死すると見積もられる。

Effect of Regulation to Gasoline

	Excess lifetime cancer risk	Annual cancer death /capita	Benzene included in Gasoline / vol %
The present condition	3.4×10^{-5}	62	2.3
Environmental agency (Target value)	1.0×10^{-5}	18	Not estimatable
Our suggestion	3.0×10^{-5}	54	1.85

The concentration of benzene in gasoline should be reduced to 1.85 vol % from 2.3 vol % to reduce the cancer risk to 3×10^{-5} from 3.4×10^{-5} .

But a uniform regulation leave the regional difference.
一律規制では地域差は残る

The Feature of Benzene Problem

ベンゼン問題の特徴

The general public directly purchase gasoline at gas stations.

多くの人が直接ガソリンを購入し消費している。

Diesel engine don't use gasoline but light oil.

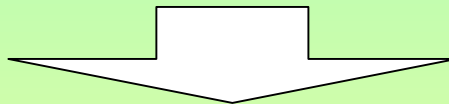
Light oil don't include benzene.

Industrial automobiles (Truck and Bus) ship Diesel.

主に産業用自動車に搭載されるディーゼルエンジンは軽油を使うためベンゼンをあまり排出しない。

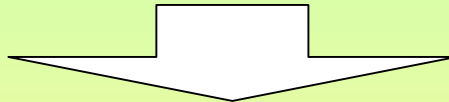
The region where pollution spread is narrow.

汚染範囲 が広くない



Who consume gasoline

Who suffer from benzene



The consumer can manage their own risk

The Future of Benzene Problem

Desirable situation from a viewpoint of consumer

消費者の立場から見た望ましい状況

Each person can choose and buy his/her favorite gasoline from various one different in benzene concentration, price and performance.

ベンゼン濃度、価格、性能などの異なる多種のガソリンから、自分の好みに合ったものを選んで買えること。

Display of benzene concentration and others to gasoline at gas-station.

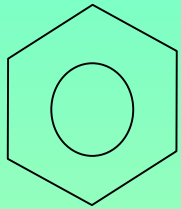
スタンドでのガソリンへのベンゼン濃度などの表示。

Easiness to get right and plain information about the toxicity of benzene.

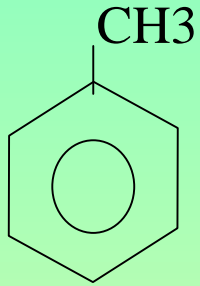
ベンゼンの毒性について、正しくわかりやすい情報がたやすく得られること。

Open to the public of information about concentration and risk of benzene at each region.

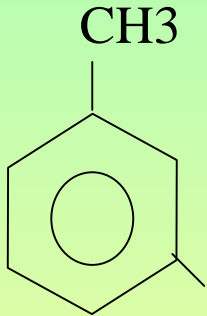
地域ごとのベンゼン濃度やリスクの大きさの公開。



Benzene
ベンゼン



Toluene
トルエン



Xylene
キシレン
CH3